APPENDIX G
INTERNATIONAL BROADBAND DATA REPORT

Section I. Country List

Section II. Broadband Deployment Comparisons

Section III. Broadband Speed and Performance Comparisons

Section IV. Broadband Pricing Comparisons

I. COUNTRY LIST

1. The Commission must include "information comparing the extent of broadband service capability (including data transmission speeds and price for broadband service capability) in a total of 75 communities in at least 25 countries abroad for each of the data rate benchmarks for broadband service utilized by the Commission to reflect different speed tiers."[1] We must choose international communities comparable to various communities in the United States with respect to population size, population density, topography, and demographic profile.[2] The Commission is required to include "a geographically diverse selection of countries" and "communities including the capital cities of such countries."[3]

2. In the table below, we list the United States and the other 37 Organisation for Economic Co-operation and Development (OECD) countries for purposes of this *International Broadband Data Report* (*2022 IBDR*) and identify the countries that are included in each section with an "X" mark.[4] We refer to these countries as the "comparison countries." For the fixed and mobile deployment comparisons, we rely on 26 European comparison countries.[5] For the fixed and mobile speed and performance comparison, we include 35 OECD Member countries.[6] For the fixed and mobile broadband pricing comparisons, we rely on a smaller subset of 25 comparison countries.[7]

[1] 47 U.S.C. § 1303(b)(1); *see also* Section 401 of the Repack Airwaves Yielding Better Access for Users of Modern Services Act of 2018, Pub. L. No. 115-141, 132 Stat. 1087 (codified at 47 U.S.C. § 163) (2018) (RAY BAUM'S Act).

[2] 47 U.S.C. § 1303(b)(2).

[3] *Id*.

[4] For previous reports, *see, e.g.*, *Communications Marketplace Report et al.*, GN Docket No. 20-60, Report, 36 FCC Rcd 2945, Appx. G: International Broadband Data Report (2020) (*2020 International Broadband Data Report*); *International Comparison Requirements Pursuant to the Broadband Data Improvement Act; International Broadband Data Report*, GN Docket No. 17-199, Sixth Report, 33 FCC Rcd 978 (IB 2018) (*Sixth International Broadband Data Report*).

[5] For the deployment section, we rely on data from the European Commission (EC) for European OECD countries and FCC Form 477 data for the United States, but we do not have comparable data for other OECD countries to be included in this analysis. Nevertheless, in section II.E, we report high-level summary statistics related to the broadband deployment for some of these non-EC OECD countries, such as Colombia and Costa Rica, based on available data.

[6] Colombia and Costa Rica are the only OECD countries not included in the speed and performance ranking comparisons because of the unavailability of data before they became OECD member countries in April 2020 and May 2021, respectively.

[7] The countries excluded from the pricing analysis are Chile, Colombia, Costa Rica, Hungary, Israel, Japan, Lithuania, Poland, Slovakia, Slovenia, South Korea, and Turkey. Due to the time intensive nature of collecting both fixed broadband and mobile broadband pricing data from multiple providers in each country, we limited the pricing analysis to the same countries analyzed in the pricing analysis of the *2020 International Broadband Data Report*. *See 2020 Communications Marketplace Report*, 36 FCC Rcd at 3750, Appx. G-1: International Broadband Data Report, para. 2.

Country[8]	Section II. Deployment	Section III. Speed & Performance	Section IV. Price
Australia (AU)		X	X
Austria (AT)	X	X	X
Belgium (BE)	X	X	X
Canada (CA)		X	X
Chile (CL)		X	
Colombia (CO)			
Costa Rica (CR)			
Czech Republic (CZ)	X	X	X
Denmark (DK)	X	X	X
Estonia (EE)	X	X	X
Finland (FI)	X	X	X
France (FR)	X	X	X
Germany (DE)	X	X	X
Greece (GR)	X	X	X
Hungary (HU)	X	X	
Iceland (IS)	X	X	X
Ireland (IE)	X	X	X
Israel (IL)		X	
Italy (IT)	X	X	X
Japan (JP)		X	
Latvia (LV)	X	X	X
Lithuania (LT)	X	X	
Luxembourg (LU)	X	X	X
Mexico (MX)		X	X
Netherlands (NL)	X	X	X
New Zealand (NZ)		X	X
Norway (NO)	X	X	X
Poland (PL)	X	X	
Portugal (PT)	X	X	X
Slovakia (SK)	X	X	
Slovenia (SI)	X	X	
South Korea (KR)		X	
Spain (ES)	X	X	X
Sweden (SE)	X	X	X
Switzerland (CH)	X	X	X
Turkey (TR)		X	
United Kingdom (GB)	X	X	X
United States (US)	X	X	X

[8] Although Colombia and Costa Rica are not included in our systematic analyses, we provide high-level deployment statistics for these countries in section II.E.

II. BROADBAND DEPLOYMENT COMPARISON

3. In this section, we present fixed and mobile broadband deployment data for the United States and 26 European comparison countries (EU 26),[9] and we report high-level summary statistics for several non-European OECD countries as well. Similar to the *Sixth International Broadband Data Report* and the *2020 International Broadband Data Report*, we use the EC's Broadband Coverage in Europe 2021 report and data[10] to compare the broadband deployment of 26 European countries with that of the United States, for which we rely upon FCC Form 477 data.

A. Comparison of European OECD Countries and United States

4. Below, we present various figures on fixed broadband deployment by technology and by speed tier and on mobile deployment by technology, for individual countries and also for an aggregate EU 26 grouping of the 26 European OECD countries.

5. Figure 1 presents the percentage of total households during 2021 with access to fixed broadband at a given download speed tier by country. Although most countries had extensive fixed broadband coverage at lower download speed tiers, the variation of fixed broadband availability across countries widened at higher download speed tiers. For instance, between 74.4% and 99.8% of households had access to fixed broadband with a download speed greater than 30 Mbps. However, the percentage of households with access to fixed broadband with a download speed greater than 1 Gbps ranged from a low of 0.9% in Slovenia to a high of 95.9% in Luxembourg. Compared to its European counterparts, the United States ranked highly in the percentage of households with access to fixed broadband at all download speed tiers. The United States ranked 9th, 7th, and 5th out of 27 countries (excluding the aggregate EU 26 grouping) in the percentage of households with access to fixed broadband with a download speed greater than 30 Mbps, 100 Mbps, and 1 Gbps, respectively.

6. Figures 2 and 3 present the percentage of total and rural households,[11] respectively, with access to fixed broadband using Fiber to the Premises (FTTP) technology by country over time. In general, the percentage of households with access to FTTP increased in all countries over time, even in rural areas. Figure 4 compares the percentages of households with access to FTTP in rural versus urban areas by country in 2021. With the exception of Denmark and the Netherlands, where rural households had slightly greater access to FTTP than urban households, the disparity in access to FTTP between rural and urban areas remained substantial in all countries in 2021. In the United States, the percentage of total households with access to FTTP increased from 29.3% in 2017 to 44.7% in 2021, and the percentage of rural households with access to FTTP increased from 16.0% in 2017 to 28.0% in 2021. Compared to its European counterparts in 2021, the United States ranked 18th out of 27 countries in the percentage of total households with access to FTTP and 16th in the percentage of rural households with access to FTTP.

7. Figure 5 presents the percentage of total households with access to fixed broadband through either DOCSIS 3.0 or 3.1 technology by country for the years 2017-2021, and Figure 6 presents

[9] In all figures, EU 26 represents all 26 European OECD countries regardless of whether individual countries are excluded from the figures due to no reported deployment in the country (i.e., the households for countries with zero deployment are included in the EU 26 denominator).

[10] *See generally* European Commission, Broadband Coverage in Europe 2021 (2022), https://digital-strategy.ec.europa.eu/en/library/broadband-coverage-europe-2021 (Broadband Coverage in Europe 2021 Report/Broadband Coverage in Europe 2021 Data) (the report and associated data can be accessed by clicking on the appropriate item listed under the "Downloads" sub header).

[11] The Broadband Coverage in Europe 2021 Report defines rural areas using a methodology that incorporates "the Corine land cover database" and "creates a database of population and land type in every square kilometre across Europe." Broadband Coverage in Europe 2021 Report at 22. Households "in square kilometres with a population of less than one hundred" are classified as rural. *Id*.

the percentage of rural households with access to fixed broadband through either DOCSIS 3.0 or 3.1 technology. Figure 7 compares the percentages of households with access to fixed broadband through either DOCSIS 3.0 or 3.1 technology in rural versus urban areas by country in 2021, and Figure 8 presents a similar comparison by focusing only on DOCSIS 3.1 technology. Compared to its European counterparts in 2021, the United States ranked 5th out of 27 countries in the percentage of total households, and 4th out of 27 countries in the percentage of rural households, with access to fixed broadband through either DOCSIS 3.0 or 3.1 technology.

8. Figure 9 presents the percentage of total households with access to mobile broadband using 4G Long-Term Evolution (LTE) by country for the years 2017-2021, and Figure 10 presents the percentage of rural households with access to 4G LTE. Figures 11 and 12 compare the percentages of households with access to mobile broadband service through 4G LTE and 5G networks, respectively, in rural versus urban areas by country in 2021. Although 4G LTE coverage was nearly ubiquitous, with the lowest coverage occurring in the rural areas of Iceland still above 93%, 5G networks were deployed mostly in urban areas. In comparison to its European counterparts, the United States ranked 5th out of 27 countries in the percentage of total households, and 2nd out of 27 countries in the percentage of rural households, with access to 5G networks. In 2021, 99.3% of total households and 86.0% of rural households in the United States had access to 5G networks.

Fig. 1. Fixed Broadband by Download Speed Tier – Percentage of Total Households (2021)

Country	≥ 30 Mbps	≥ 100 Mbps	≥ 1 Gbps
Austria	93.3%	82.8%	45.4%
Belgium	99.1%	97.2%	69.0%
Czech Republic	98.1%	89.2%	38.1%
Denmark	97.7%	96.3%	90.7%
EU 26	90.5%	79.7%	59.4%
Estonia	89.2%	83.5%	36.7%
Finland	77.0%	65.0%	51.0%
France	74.4%	65.3%	63.8%
Germany	95.9%	89.6%	62.1%
Greece	96.6%	54.6%	19.0%
Hungary	94.9%	88.7%	44.8%
Iceland	98.8%	88.3%	85.6%
Ireland	90.1%	87.7%	67.4%
Italy	90.6%	77.6%	44.2%
Latvia	93.5%	90.7%	40.3%
Lithuania	84.6%	78.1%	78.0%
Luxembourg	99.8%	99.4%	95.9%
Netherlands	99.2%	98.5%	88.8%
Norway	91.7%	89.2%	86.5%
Poland	77.0%	69.2%	55.2%
Portugal	92.8%	92.8%	86.0%
Slovakia	82.3%	75.4%	28.0%
Slovenia	89.5%	85.5%	0.9%
Spain	96.2%	93.8%	92.5%
Sweden	88.9%	86.7%	82.5%
Switzerland	99.8%	98.6%	63.7%
United Kingdom	95.0%	63.2%	38.7%
United States	96.3%	93.4%	86.7%

Fig. 2. Fixed Broadband - FTTP – Percentage of Total Households (2017-2021)

Country	2017	2018	2019	2020	2021
Austria	12.4%	13.0%	13.8%	20.5%	26.6%
Belgium	0.8%	1.4%	3.6%	6.5%	9.7%
Czech Republic	25.9%	28.3%	29.3%	33.3%	35.8%
Denmark	62.7%	64.4%	66.9%	70.1%	74.1%
EU 26	24.8%	28.1%	32.7%	37.7%	44.8%
Estonia	50.7%	54.2%	57.4%	70.9%	73.4%
Finland	31.7%	31.4%	35.2%	37.7%	40.0%
France	28.3%	37.8%	43.8%	52.6%	63.4%
Germany	7.3%	8.5%	10.5%	13.8%	15.4%
Greece	0.4%	0.4%	7.1%	10.2%	19.8%
Hungary	29.8%	35.9%	42.6%	48.6%	64.2%
Iceland	72.3%	76.2%	80.4%	83.5%	87.6%
Ireland	8.3%	12.9%	35.4%	47.7%	62.2%
Italy	21.7%	23.9%	30.0%	33.7%	44.2%
Latvia	85.7%	87.8%	88.1%	88.1%	89.5%
Lithuania	54.4%	60.6%	61.0%	67.1%	78.2%
Luxembourg	57.2%	63.4%	67.5%	72.1%	75.2%
Netherlands	31.9%	32.2%	34.4%	35.6%	51.9%
Norway	51.9%	58.7%	71.4%	73.7%	75.3%
Poland	21.3%	29.1%	38.3%	44.6%	51.9%
Portugal	63.6%	70.2%	76.6%	82.3%	87.6%
Slovakia	41.2%	42.9%	44.3%	49.2%	62.3%
Slovenia	52.2%	61.1%	63.8%	65.6%	72.5%
Spain	71.4%	77.4%	80.4%	84.9%	88.9%
Sweden	66.4%	72.2%	77.1%	80.5%	82.5%
Switzerland	29.5%	30.3%	34.9%	39.7%	40.2%
United Kingdom	3.0%	3.8%	8.5%	14.5%	23.3%
United States	29.3%	33.8%	41.1%	42.4%	44.7%

Fig. 3. Fixed Broadband - FTTP – Percentage of Rural Households (2017-2021)

Country	2017	2018	2019	2020	2021
Austria	5.4%	5.9%	10.0%	10.6%	14.9%
Belgium	0.0%	0.0%	0.1%	0.4%	0.7%
Czech Republic	5.3%	5.6%	5.9%	6.4%	6.9%
Denmark	54.8%	60.8%	65.8%	70.9%	77.8%
EU 26	9.4%	13.4%	17.5%	23.4%	30.2%
Estonia	16.8%	18.0%	19.8%	20.5%	21.1%
Finland	8.3%	9.3%	9.1%	9.4%	12.4%
France	4.3%	9.3%	12.4%	18.4%	28.8%
Germany	2.4%	3.6%	5.6%	10.6%	11.3%
Greece	0.0%	0.0%	0.0%	0.0%	0.0%
Hungary	6.8%	15.6%	28.9%	35.6%	37.9%
Iceland	29.1%	39.4%	54.7%	66.3%	78.4%
Ireland	1.2%	2.7%	13.5%	20.6%	43.1%
Italy	0.8%	0.8%	2.1%	8.4%	17.3%
Latvia	70.1%	73.6%	73.2%	73.8%	75.2%
Lithuania	19.5%	21.8%	22.5%	23.3%	41.1%
Luxembourg	35.1%	37.0%	41.5%	48.5%	51.1%
Netherlands	20.3%	22.7%	26.4%	27.2%	54.5%
Norway	22.9%	32.6%	44.8%	56.3%	64.0%
Poland	9.5%	13.7%	17.9%	24.1%	32.6%
Portugal	42.2%	48.2%	49.1%	51.2%	60.7%
Slovakia	9.2%	11.9%	15.3%	18.0%	21.6%
Slovenia	25.8%	34.3%	38.0%	39.0%	46.4%
Spain	20.9%	32.6%	46.4%	59.5%	68.9%
Sweden	22.2%	31.0%	40.6%	48.1%	54.3%
Switzerland	7.6%	8.2%	8.6%	20.4%	21.1%
United Kingdom	4.3%	5.9%	8.1%	11.9%	16.2%
United States	16.0%	17.4%	20.9%	23.9%	28.0%

Fig. 4. Fixed Broadband - FTTP - Percentage of Rural and Urban Households (2021)

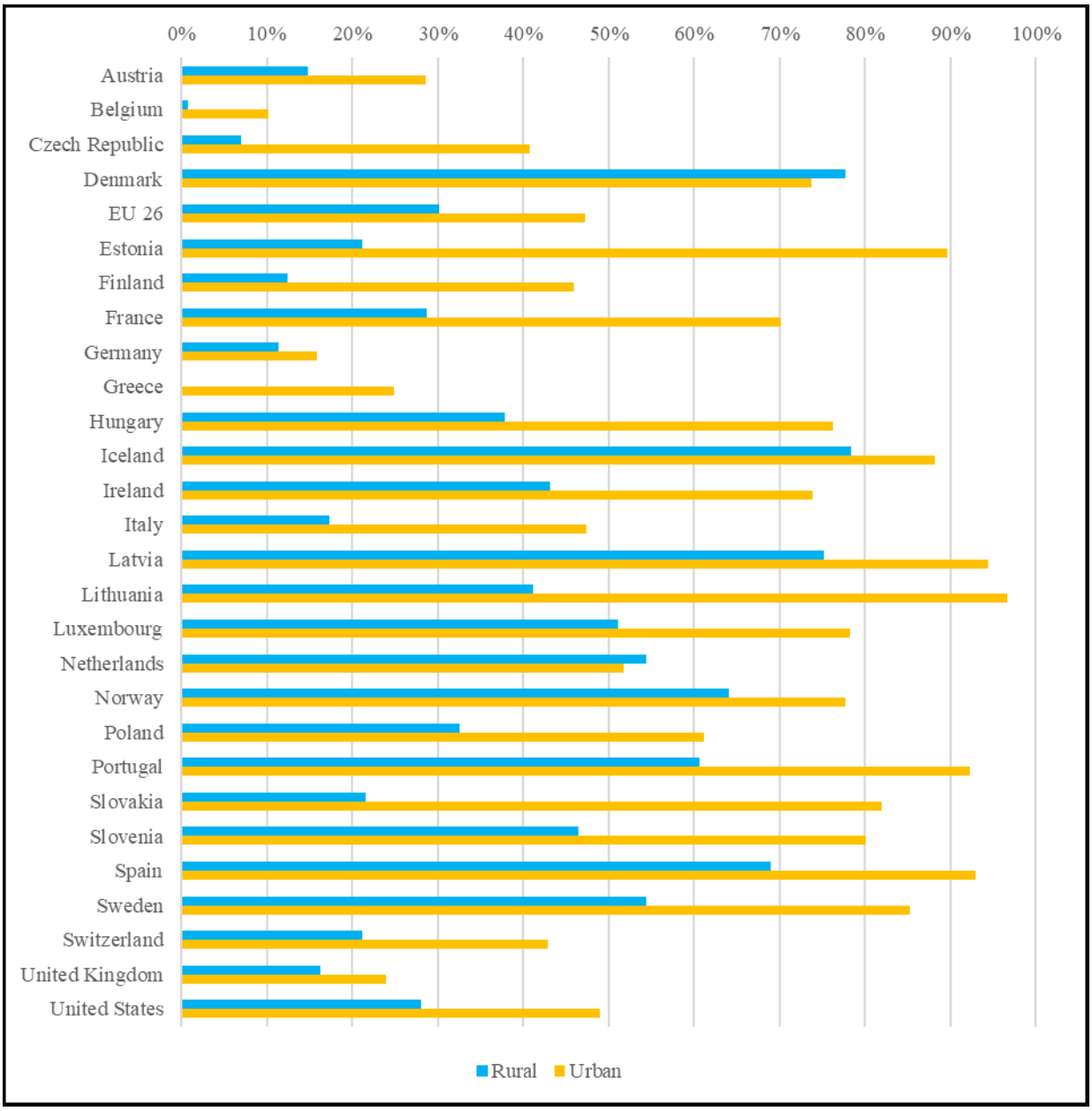


Fig. 5. Fixed Broadband – DOCSIS 3.0/3.1 – Percentage of Total Households (2017-2021)[12]

Country	2017	2018	2019	2020	2021
Austria	51.8%	53.0%	53.2%	58.3%	59.3%
Belgium	93.9%	93.9%	93.5%	93.6%	96.5%
Czech Republic	38.8%	41.5%	41.1%	41.6%	41.9%
Denmark	68.8%	68.4%	68.4%	68.1%	67.5%
EU 26	44.1%	45.1%	46.0%	46.1%	45.3%
Estonia	55.6%	65.7%	67.4%	76.7%	78.5%
Finland	36.2%	36.1%	36.9%	37.8%	36.9%
France	27.8%	28.6%	27.0%	27.0%	23.1%
Germany	63.7%	63.9%	66.3%	66.9%	67.9%
Greece	0.0%	0.0%	0.5%	0.6%	0.0%
Hungary	68.3%	71.5%	74.5%	76.0%	78.2%
Iceland	0.0%	0.0%	0.3%	0.3%	3.3%
Ireland	48.6%	48.7%	49.2%	49.8%	48.6%
Latvia	29.2%	29.4%	30.1%	30.1%	30.2%
Lithuania	17.1%	18.1%	17.9%	19.4%	27.1%
Luxembourg	73.2%	84.0%	83.9%	88.9%	90.2%
Netherlands	95.1%	95.1%	95.2%	95.2%	94.2%
Norway	51.3%	49.0%	45.1%	44.5%	40.3%
Poland	39.4%	40.0%	44.1%	43.4%	43.9%
Portugal	56.2%	56.3%	59.5%	59.4%	57.6%
Slovakia	29.7%	30.0%	32.2%	32.9%	39.4%
Slovenia	57.4%	59.9%	57.6%	58.7%	58.5%
Spain	48.8%	48.9%	48.9%	45.8%	38.4%
Sweden	36.8%	36.0%	35.7%	37.3%	35.8%
Switzerland	84.3%	84.3%	84.4%	84.3%	85.2%
United Kingdom	46.4%	50.1%	50.3%	50.3%	50.3%
United States	87.9%	88.4%	88.4%	88.3%	84.5%

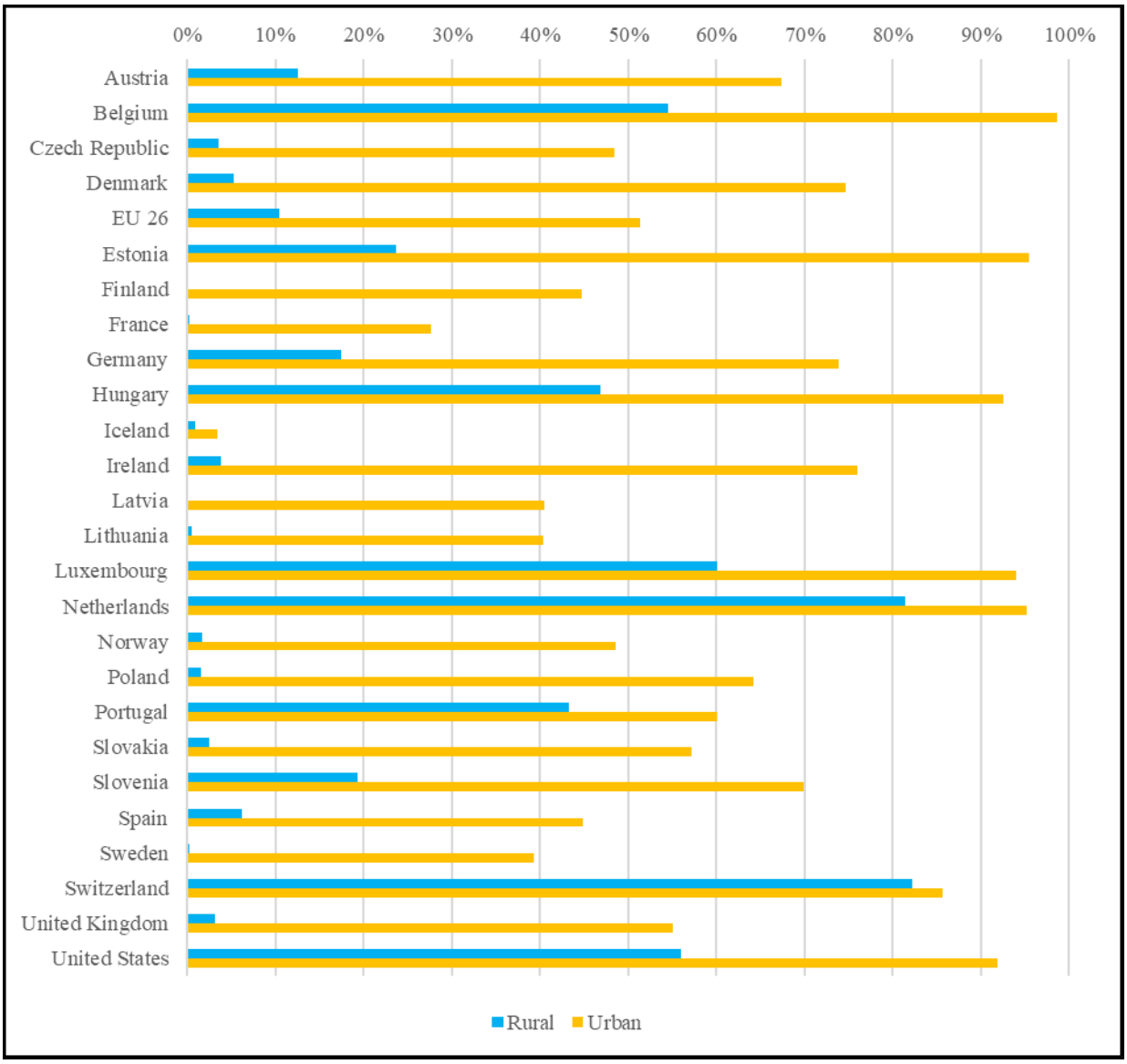
[12] The Broadband Coverage in Europe Reports from 2021, 2020, and 2019 indicate that Italy had no deployment of DOCSIS 3.0/3.1 from 2017 to 2021. Broadband Coverage in Europe 2021 Report at 124; European Commission, Broadband Coverage in Europe 2020 at 125 (2021), https://digital-strategy.ec.europa.eu/en/library/broadband-coverage-europe-2020 (Broadband Coverage in Europe 2020 Report) (the report and associated data can be accessed by clicking on the appropriate item listed under the "Downloads" sub header); European Commission, Broadband Coverage in Europe 2019 at 124 (2020), https://digital-strategy.ec.europa.eu/en/library/broadband-coverage-europe-2019 (Broadband Coverage in Europe 2019 Report) (the report and associated data can be accessed by clicking on the appropriate item listed under the "Downloads" sub header). EU 26 includes all 26 countries, including Italy.

Fig. 6. Fixed Broadband – DOCSIS 3.0/3.1 – Percentage of Rural Households (2017-2021)[13]

Country	2017	2018	2019	2020	2021
Austria	19.9%	19.9%	20.4%	21.2%	12.6%
Belgium	45.2%	45.5%	48.3%	48.5%	54.6%
Czech Republic	2.4%	3.2%	3.4%	3.5%	3.6%
Denmark	5.6%	5.2%	5.9%	5.5%	5.3%
EU 26	9.2%	10.0%	10.7%	10.7%	10.5%
Estonia	12.7%	23.3%	23.5%	23.6%	23.7%
France	1.1%	1.3%	0.7%	0.7%	0.3%
Germany	15.0%	15.2%	16.9%	16.9%	17.5%
Hungary	25.3%	37.8%	47.1%	47.1%	46.9%
Iceland	0.0%	0.0%	0.0%	0.0%	1.0%
Ireland	3.4%	3.4%	3.7%	3.7%	3.8%
Lithuania	0.2%	0.3%	0.4%	0.5%	0.5%
Luxembourg	0.0%	32.6%	33.0%	62.9%	60.1%
Netherlands	66.2%	69.0%	74.0%	74.8%	81.4%
Norway	4.5%	2.6%	2.9%	1.5%	1.7%
Poland	1.4%	1.5%	1.5%	1.5%	1.6%
Portugal	43.1%	43.3%	43.5%	43.5%	43.3%
Slovakia	0.3%	0.5%	1.2%	1.7%	2.6%
Slovenia	20.6%	21.1%	19.7%	19.8%	19.3%
Spain	12.6%	13.1%	11.2%	10.8%	6.3%
Sweden	0.3%	0.3%	0.3%	0.3%	0.3%
Switzerland	78.1%	79.7%	79.8%	79.6%	82.2%
United Kingdom	2.2%	3.1%	3.1%	3.1%	3.2%
United States	53.3%	54.7%	54.6%	54.6%	55.9%

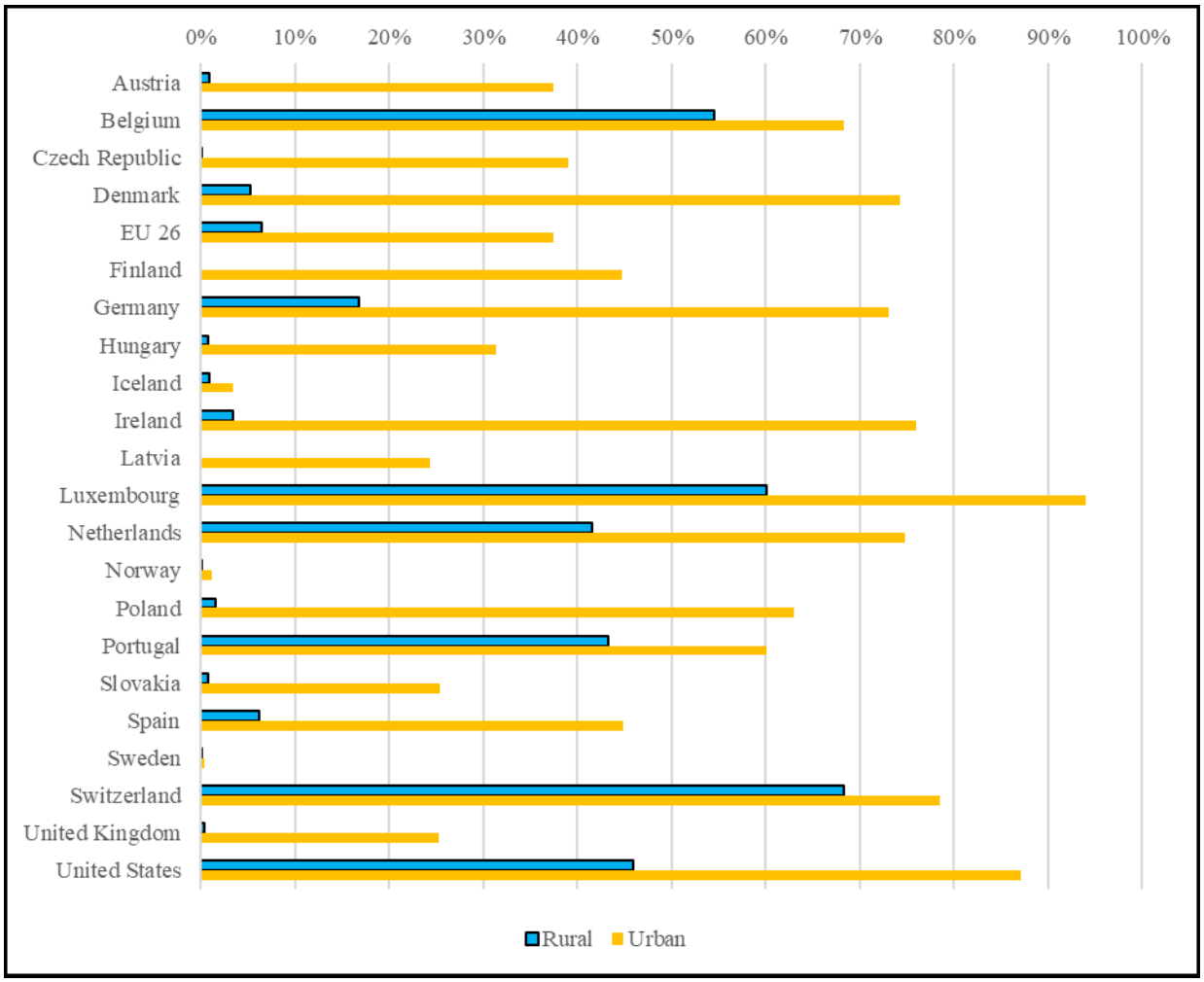
[13] The Broadband Coverage in Europe Reports from 2021, 2020, and 2019 indicate that Finland, Greece, Italy, and Latvia had no deployment of DOCSIS 3.0/3.1 for rural households from 2017 to 2021. Broadband Coverage in Europe 2021 Report at 92, 107, 124, 128; Broadband Coverage in Europe 2020 Report at 93, 108, 125, 129; Broadband Coverage in Europe 2019 Report at 91, 107, 124, 128. EU 26 includes all 26 countries, including Finland, Greece, Italy, and Latvia.

Fig. 7. Fixed Broadband - DOCSIS 3.0/3.1 – Percentage of Rural and Urban Households (2021)[14]



[14] The Broadband Coverage in Europe 2021 Report indicates that Italy and Greece had no deployment of DOCSIS 3.0/3.1 in 2021; however, the report also indicates that Greece had some deployment in prior years. Broadband Coverage in Europe 2021 Report at 107, 124. EU 26 includes all 26 countries, including Italy and Greece.

Fig. 8. Fixed Broadband - DOCSIS 3.1 – Percentage of Rural and Urban Households (2021)[15]



[15] The Broadband Coverage in Europe 2021 Report indicates that Estonia, France, Greece, Italy, Lithuania, and Slovenia had no DOCSIS 3.1 deployment in 2021. Broadband Coverage in Europe 2021 Report at 87, 97, 107, 124, 132, 169. EU 26 includes all 26 countries, including Estonia, France, Greece, Italy, Lithuania, and Slovenia.

Fig. 9. Mobile Broadband – 4G LTE – Percentage of Total Households (2017-2021)

Country	2017	2018	2019	2020	2021
Austria	99.01%	99.46%	99.56%	99.97%	99.96%
Belgium	99.99%	99.99%	100.00%	100.00%	100.00%
Czech Republic	99.41%	99.41%	99.84%	99.79%	99.84%
Denmark	100.00%	100.00%	100.00%	100.00%	100.00%
EU 26	98.28%	99.06%	99.40%	99.73%	99.77%
Estonia	98.45%	99.25%	99.42%	100.00%	99.69%
Finland	99.64%	99.98%	99.99%	99.99%	100.00%
France	97.99%	99.34%	99.54%	99.79%	99.92%
Germany	96.50%	97.50%	98.61%	99.71%	99.98%
Greece	93.98%	98.18%	99.12%	99.19%	99.50%
Hungary	99.20%	99.20%	99.21%	99.30%	99.74%
Iceland	98.56%	99.88%	99.92%	99.92%	99.67%
Ireland	97.16%	95.84%	99.00%	99.00%	99.00%
Italy	98.69%	98.87%	98.88%	99.31%	99.95%
Latvia	98.43%	98.60%	99.95%	99.95%	99.95%
Lithuania	99.08%	99.18%	99.96%	99.97%	99.98%
Luxembourg	98.60%	98.67%	99.79%	99.80%	99.80%
Netherlands	99.35%	99.35%	99.40%	99.50%	96.37%
Norway	99.72%	99.83%	99.90%	99.93%	99.98%
Poland	99.90%	99.95%	99.90%	99.90%	99.90%
Portugal	98.89%	99.21%	99.73%	99.85%	99.84%
Slovakia	96.29%	97.37%	98.40%	98.40%	98.40%
Slovenia	98.57%	99.51%	99.70%	99.93%	99.94%
Spain	97.22%	99.53%	99.77%	99.87%	99.91%
Sweden	100.00%	100.00%	100.00%	100.00%	100.00%
Switzerland	99.80%	99.90%	99.94%	99.90%	99.99%
United Kingdom	99.50%	99.87%	99.87%	99.93%	99.91%
United States	99.81%	99.87%	99.90%	99.91%	99.62%

Fig. 10. Mobile Broadband – 4G LTE – Percentage of Rural Households (2017-2021)

Country	2017	2018	2019	2020	2021
Austria	92.72%	96.41%	96.60%	99.93%	99.74%
Belgium	99.74%	99.73%	100.00%	100.00%	100.00%
Czech Republic	95.84%	95.85%	99.82%	99.77%	99.83%
Denmark	100.00%	100.00%	100.00%	100.00%	100.00%
EU 26	92.20%	96.73%	98.34%	98.69%	99.56%
Estonia	98.45%	99.25%	99.55%	100.00%	99.38%
Finland	99.99%	99.87%	99.92%	99.93%	100.00%
France	87.50%	99.77%	99.76%	99.15%	99.74%
Germany	87.90%	90.60%	96.74%	98.56%	99.93%
Greece	75.98%	93.50%	95.76%	96.08%	97.57%
Hungary	97.71%	97.70%	97.70%	98.16%	99.61%
Iceland	94.92%	98.65%	99.13%	99.13%	93.95%
Ireland	91.60%	92.70%	97.01%	97.41%	97.36%
Italy	89.19%	90.66%	95.01%	94.74%	99.94%
Latvia	94.40%	94.96%	99.81%	99.82%	99.80%
Lithuania	96.97%	97.28%	99.88%	99.90%	99.98%
Luxembourg	95.18%	95.94%	99.57%	99.60%	99.80%
Netherlands	99.35%	99.40%	99.28%	99.28%	98.64%
Norway	99.60%	99.61%	99.88%	99.90%	99.90%
Poland	99.79%	99.90%	99.90%	99.90%	99.90%
Portugal	93.54%	94.58%	98.16%	98.96%	98.94%
Slovakia	87.10%	90.86%	94.39%	94.39%	95.24%
Slovenia	95.07%	98.16%	98.81%	99.71%	99.76%
Spain	87.02%	97.53%	98.82%	99.28%	100.00%
Sweden	99.98%	99.99%	99.99%	99.99%	99.99%
Switzerland	99.38%	99.69%	99.79%	99.90%	99.95%
United Kingdom	95.41%	99.35%	99.35%	99.26%	99.01%
United States	99.08%	99.38%	99.53%	99.58%	98.17%

Fig. 11. Mobile Broadband – 4G LTE – Percentage of Rural and Urban Households (2021)

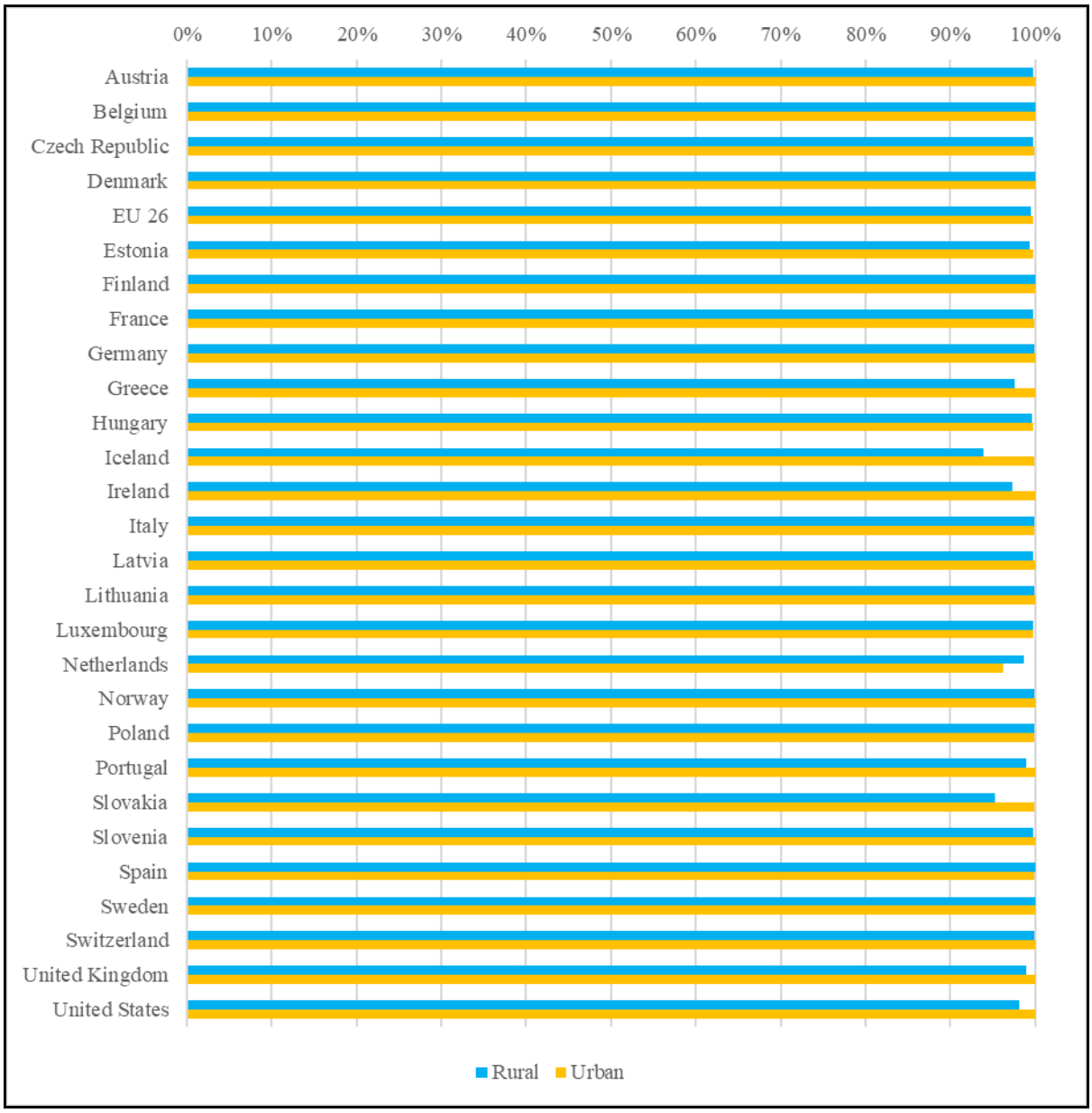
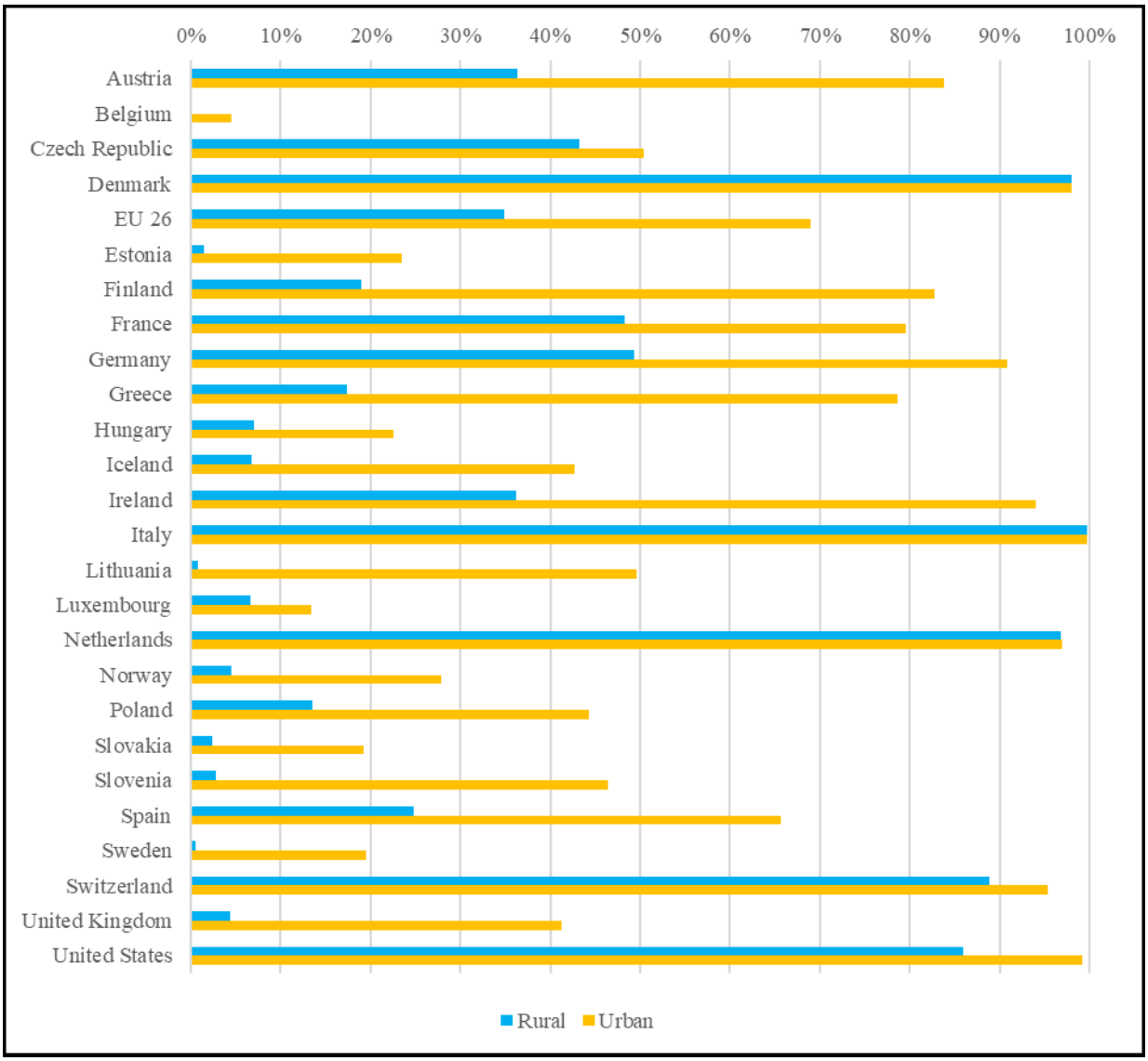


Fig. 12. Mobile Broadband – 5G – Percentage of Rural and Urban Households (2021)[16]



[16] The Broadband Coverage in Europe 2021 Report indicates that Latvia and Portugal had no reported 5G deployment in 2021. Broadband Coverage in Europe 2021 Report at 128, 157. EU 26 includes all 26 countries, including Latvia and Portugal.

B. Summary of Broadband Coverage in Europe 2021 Report Methodology

9. For the Broadband Coverage in Europe 2021 Report, a survey of national regulators and broadband network operators was conducted and validated against other available data (e.g., market reports, Internet service providers' (ISPs) financial reports and press releases, etc.).[17] Survey respondents were asked to submit the number of total and rural households passed in each nomenclature of territorial units for statistics (NUTS) 3 region (regional units of 150,000 to 800,000 inhabitants) by technology or set of technologies.[18] In addition, respondents were also asked to provide the number of households passed by networks that are able to achieve download speeds of at least 30 Mbps, 100 Mbps, and 1 Gbps.[19]

10. Survey respondents were provided with estimates of the number of total households and rural households in each NUTS 3 region by using the NUTS 3 level population data and average household size data published annually by Eurostat for each country.[20] To determine the number of rural households in each NUTS 3 region, the report's research team uses the Corine land cover database to determine the population and land type of each square kilometer in Europe; households in square kilometers with a population of less than 100 (i.e., a population density of less than 100 per square kilometer) are classified as rural.[21] Based on the survey of regulators and providers and supplemental research, data were integrated on a country-by-country basis by technology at the NUTS 3 level which were then aggregated to the national level by technology.[22] The integration process accounted for areas in which coverage of the same technology was provided by multiple operators to avoid double counting households.[23]

11. To estimate coverage by download speed tier, the survey included questions asking respondents to report the number of households at the country-level that realistically could achieve actual download speeds of at least 30 Mbps, 100 Mbps, and 1 Gbps.[24] For each speed tier, the set of technologies capable of reaching the speed were specified and respondents were asked to exclude connections that did not meet the criteria.[25] To qualify for the speed tier, the connection must be able to achieve the minimum speed 75% of the time.[26]

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[17] Broadband Coverage in Europe 2021 Report at 21.

[18] *Id*. at 18.

[19] *Id*. at 21.

[20] Updated annual household values are not available for all relevant countries. Therefore, the Broadband Coverage in Europe 2021 Report estimates annual number of households using NUTS 3 population and average household size data and uses these estimates for all countries for consistency. *See id*. at 22.

[21] *Id*. at 22.

[22] *Id*. at 23.

[23] *Id*..

[24] *Id*. at 23-24.

[25] For the 30 Mbps tier, the category included Very-high-bit-rate Digital Subscriber Line (VDSL, including VDSL2 Vectoring), FTTP, Fixed Wireless Access (FWA, including 4G TD LTE standard and 5G FWA), and DOCSIS 3.0 (including DOCSIS 3.1) cable broadband. *See id*.at 24. For the 100 Mbps tier, the category included VDSL2 Vectoring, FTTP, DOCSIS 3.0/3.1 cable broadband, and 5G FWA (if speeds higher than 100 Mbps are attainable over 5G FWA). *See id*. For the 1 Gbps tier, the category included FTTP and DOCSIS 3.1 cable broadband. *See id*.

[26] *Id*.

12. Regarding 5G coverage, the EC's research team used official regulatory data on 5G rollouts in addition to reviewing information published by network operators on the cities and areas where their 5G networks and services had been launched.[27]

C. Summary of Methodology to Compare FCC Form 477 Data with Broadband Coverage in Europe 2021 Data

13. For our comparative analysis of European OECD countries with the United States,[28] we rely upon FCC Form 477 fixed broadband and mobile broadband deployment data.[29] Although the Broadband Coverage in Europe 2021 Data and the FCC Form 477 data are collected under different methodologies and definitions, we use the census block level FCC Form 477 data to recreate the statistics by technology and speed tiers at overall and rural breakdowns for the United States. Below, we describe our methodology for using the FCC Form 477 data to make the most accurate comparison with the EC statistics as possible.

14. For fixed broadband comparisons, we use the FCC Form 477 data at five vintage points—June 2017, June 2018, June 2019, June 2020, and June 2021. FCC Form 477 fixed broadband data indicate whether a provider deploys a specific technology to at least one location in each census block, along with the associated maximum download and upload speeds.[30]

15. For figures presenting deployment by technology (or set of technologies), we identify each block that is covered by at least one provider with the technology (or set of technologies),[31] and assume that all households in the census block are covered.[32] Then, we aggregate block-level coverage to the national level for total, urban, and rural[33] households and divide them, respectively, by total, urban, and rural households to calculate the percentage of covered households.[34]

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[27] *Id*. at 25.

[28] Our analysis includes the 50 U.S. states and Washington, D.C. (i.e., we do not include any U.S. territories).

[29] FCC, *Form 477 Resources*, https://www.fcc.gov/economics-analytics/industry-analysis-division/form-477-resources (last visited Oct. 6, 2022). All FCC Form 477 data used in this *2022 IBDR* have been certified as accurate by the filers. We note that the *2022 IBDR*'s analysis may understate or overstate consumers' options for services to the extent that broadband providers fail to report data or misreport data. *See* FCC, *Explanation of Broadband Deployment Data*, https://www.fcc.gov/general/explanation-broadband-deployment-data (last visited Oct. 6, 2022) (describing quality and consistency checks performed on providers' submitted data and explaining any adjustments made to the FCC Form 477 data as filed).

[30] Census block populations range from 0 to about 19,000, and households range from 0 to about 2,600.

[31] We match the broadband technologies collected in the Broadband Coverage in Europe 2021 Report with the FCC Form 477 technology codes described below. To match the EC Cable Modem DOCSIS 3.0 definition, which includes DOCSIS 3.1, we use the FCC Form 477 technology codes 42 (Cable Modem – DOCSIS 3.0) and 43 (Cable Modem DOCSIS 3.1), but do not include 41 (Cable Modem – DOCSIS 1, 1.1, and 2.0) or 44 (Cable Modem – DOCSIS 4.0). To match the European FTTP definitions, we use the FCC Form 477 technology code 50 (Optical Carrier / Fiber to the End User).

[32] A block is defined as covered by a set of technologies if the block is covered by at least one of the technologies in the set.

[33] For the U.S. urban and rural classifications, we use the U.S. Census Bureau classifications of Urbanized Area and Urban Clusters to identify each census block as urban, with non-urban blocks being classified as "rural." U.S. Census Bureau, *2010 Census Urban and Rural Classification and Urban Area Criteria* (Oct. 28, 2021), https://www.census.gov/programs-surveys/geography/guidance/geo-areas/urban-rural/2010-urban-rural.html.

[34] Due to data unavailability, 2021 household estimates are calculated using 2020 data. *See* FCC, *Staff Block Estimates*, https://www.fcc.gov/economics-analytics/industry-analysis-division/staff-block-estimates (Staff Block Estimates) (last visited Oct. 6, 2022).

16. For figures presenting deployment by download speed tier, we follow a similar approach as described above for figures presenting deployment by technology or set of technologies. For download speed tiers, the Broadband Coverage in Europe 2021 Report categorizes households by technology and download speed so households with a particular technology deployed, but not at the download speed threshold, are excluded from the household count; therefore, we use the technology codes to identify blocks with the relevant technology (or set of technologies) deployed but exclude census blocks that do not meet the download speed threshold.

17. For mobile broadband comparisons, we use the most recent version of FCC Form 477 Actual Area methodology deployment data dated June of each year between 2017 and 2021 to estimate the number of households covered by at least one provider of the 4G LTE or 5G technology. For each census block, we use the percentage of area covered and assume households are uniformly distributed within the census block (i.e., if 10% of the census block is covered by at least one provider, we assumed 10% of households in that block are covered). For annual block level estimates of households, we use the FCC's Staff Block Estimates.[35] We then aggregate the data to the national level (total, urban, and rural) to estimate the number of households covered by each mobile broadband technology.

D. Caveats to Broadband Coverage in Europe Data and FCC Form 477 Data Comparisons

18. Given that the two data sources for the European and U.S. comparisons are independent data collections undertaken by distinct entities for different purposes, the comparisons should be interpreted carefully because definitions used by the two sources are not necessarily the same for various elements of the data collections. For instance, the definitions of rural areas are different between the Broadband Coverage in Europe 2021 Data and the U.S. data. As described above, the EC classifies a household in Europe as rural if the square kilometer where the household is located has a population of fewer than 100 persons, whereas the U.S. analysis uses the U.S. Census Bureau's classification of "urban" to define "non-urban" (i.e., rural) areas at the census block level. It is not clear how use of a consistent definition of rural households would affect the deployment figures for the various countries. Also, differences in the definitions of deployed technologies between the Broadband Coverage in Europe 2021 Data and the FCC Form 477 data may also make the comparisons imperfect. Similarly, the definition of "households" may not be identical between the U.S. Census Bureau and the EC.[36]

19. Despite these caveats, the comparisons between the European comparison countries and the United States are the best possible given the available data on broadband deployment for the comparison countries. Where possible, we have matched the national level statistics from the Broadband Coverage in Europe 2021 Data by following the most similar definitions used by the U.S. data.

E. Non-European Comparison Country Highlights

20. This section presents high-level fixed and mobile broadband deployment summary statistics for a number of non-European OECD countries. This section is not intended to be directly compared to prior comparisons between European countries and the United States and is presented here merely for informational purposes. The language used to describe the fixed broadband and mobile broadband services is drawn directly from the source materials.

21. As of 2021, 99.9% of households in Australia could access fixed broadband services; 98.5% of premises could access fixed broadband speeds of at least 25 Mbps; and approximately 75.0% of

[35] *See generally* Staff Block Estimates.

[36] Eurostat, *Glossary: Household – social statistics*, https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Glossary:Household_-_social_statistics) (last visited Oct. 6, 2022); U.S. Census Bureau, *Subject Definitions*, https://www.census.gov/programs-surveys/cps/technical-documentation/subject-definitions.html#household (last visited Oct. 6, 2022).

premises could access fixed broadband speeds of at least 100 Mbps (compared to approximately 66.0% of premises as of November 2020).[37] As of the end of March 2021, 99.3% of households in Japan could access fixed fiber optic broadband services.[38] As of June 30, 2021, 97.5% of New Zealand's population could access 4G mobile broadband services.[39] Furthermore, as of the first quarter of 2022, 86.2% of New Zealand's population could access fixed broadband speeds of at least 30 Mbps.[40]

22. As of 2020, 99.5% and 53.3% of the population in Canada could access mobile wireless services using LTE and 5G technology, respectively.[41] Additionally, in 2020, 97.7% and 15.7% of the population living in rural population centers in Canada could access mobile wireless services using LTE and 5G technology, respectively.[42] Furthermore, 96.1% of households in Canada could access fixed broadband services with download speeds of at least 25 Mbps in 2020.[43] Also, 99.7% and 82.2% of households in Canada's urban and rural population centers, respectively, could access such fixed broadband services in 2020.[44] Finally, 87.0%, 85.5%, and 75.8% of households in Canada could access fixed broadband services with download speeds of at least 100 Mbps, 200 Mbps, and 1 Gbps, respectively, as of 2020.[45]

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[37] Australian Government, Department of Infrastructure, Transport, Regional Development and Communications & Bureau of Communications, Arts and Regional Research, *Australia's Broadband Performance – statistical snapshot*, (Mar. 4, 2022), https://www.infrastructure.gov.au/department/media/publications/australias-broadband-performance-statistical-snapshot (to navigate to the statistics, click on the link to the pdf document); Australian Government, Department of Infrastructure, Transport, Regional Development and Communications & Bureau of Communications, Arts and Regional Research, Measuring Australia's fixed broadband performance – compendium at 7 (2020), https://www.infrastructure.gov.au/sites/default/files/documents/measuring-australias-fixed-broadband-performance-compendium.pdf.

[38] Press Release, Japanese Ministry of Internal Affairs and Communications, Results of Survey on Broadband Infrastructure Coverage Rate at End of FY2020 (Jan. 31, 2022), https://www.soumu.go.jp/main_sosiki/joho_tsusin/eng/pressrelease/2022/1/31_01.html (scroll down and click on "Attachment 1" under "Published Materials" subheading).

[39] Commerce Commission New Zealand, *Annual monitoring reports*, https://comcom.govt.nz/regulated-industries/telecommunications/monitoring-the-telecommunications-market/annual-telecommunications-market-monitoring-report (last visited Oct. 6, 2022) (the percentage of the population able to access 4G mobile broadband services can be accessed by navigating to the "Telecommunications industry questionnaire results" subheading, clicking on the "2021 Telecommunications industry questionnaire results – 17 March 2022" excel file, and reviewing row 153 of the "Mobile Network Operator" sheet).

[40] Crown Infrastructure Partners, Quarterly Connectivity Update Q1: to 31 March 2022 at 5 (2022), https://www.crowninfrastructure.govt.nz/wp-content/uploads/CIP-Connectivity-Quarterly-Update-Q1-March-2022.pdf.

[41] Canadian Radio-television and Telecommunications Commission, *Current trends – Mobile wireless*, https://crtc.gc.ca/eng/publications/reports/PolicyMonitoring/mob.htm (last visited Oct. 6, 2022) (in order to obtain the desired statistics, select the appropriate categories under the "Take a closer look at the availability of different mobile speeds" sub heading).

[42] *Id.*

[43] Canadian Radio-television and Telecommunications Commission, *Current trends – High-speed broadband*, https://crtc.gc.ca/eng/publications/reports/PolicyMonitoring/ban.htm (last visited Oct. 6, 2022) (in order to obtain the desired statistics, select the appropriate categories under the "Take a closer look at the availability of different broadband speeds" sub heading).

[44] *Id.*

[45] *Id.*

23. As of March 2022, 61.4% of households in Chile could access fixed Internet services.[46] As of June 15, 2021, 100% and 99% of the population in Colombia and Costa Rica, respectively, had access to mobile networks.[47] As of December 15, 2020, 91.0% of the population in Mexico had access to mobile networks.[48]

III. BROADBAND SPEED AND PERFORMANCE COMPARISONS

24. This section of the *International Broadband Data Report* presents a comparison of fixed broadband and mobile wireless broadband performance metrics in terms of data transmission speeds (download and upload speeds) and latency for the United States and 35 comparison countries. The main analysis relies solely on Ookla Speedtest datasets for both speed and latency. For fixed broadband, we consider any technologies reported in the Ookla Speedtest datasets, and for mobile broadband, we consider 4G LTE and, for the first time, 5G. In this *Report*, we present an analysis of download and upload speeds, as well as an analysis of latency, with a five-year time horizon for fixed broadband services and mobile 4G LTE broadband services.[49] We rank speeds from the fastest (1st) to the slowest (36th) and latency from the lowest (1st) to the highest (36th).

A. Fixed Broadband Speed and Latency Results

25. Figure 13 compares mean fixed broadband download speeds by country for the years 2017-2021. U.S. mean download speed ranking slipped to a ranking of 9th among the 36 countries in 2021, down from a ranking of 5th between 2018 and 2020. In 2021, the mean download speed for the United States was 195.5 Mbps, which almost tripled the mean download speed of 70.1 Mbps in 2017. Iceland had the fastest mean download speed in 2021 with a mean download speed of 253.1 Mbps.

26. Figure 14 compares mean fixed broadband upload speeds by country for the years 2017-2021. U.S. mean upload speed rankings were relatively stable for the last five years, with the United States ranking 18th of the 36 countries in 2021, and 17th in 2018-2020. The mean upload speed in 2021 for the United States was 72.9 Mbps, compared to the fastest mean upload speed of 250.6 Mbps in Iceland.

27. Figure 15 compares mean fixed broadband latency by country for the years 2017-2021. U.S. mean latency rankings slipped from appearing in the range of 24th to 26th in 2017-2019 to 30th in 2020 and 29th in 2021. The mean latency for the United States in 2021 was 21.3 ms, compared to Iceland's mean latency of 10.8 ms in 2021, which ranked the best out of the 36 countries.

28. Figure 16 compares mean fixed broadband download speeds by country and U.S. state capital cities for the years 2017-2021. The mean download speed in Washington D.C. in 2021 was 185.9 Mbps, which ranked 38th among the 86 country and state capital cities. The highest ranked U.S. capital city in 2021 was Dover, Delaware, which ranked 2nd with a mean download speed of 243.6 Mbps. Other

[46] Ministerio de Transportes y Telecomunicaciones, Especial Analisis Nueva Tecnologia 5G en Internet Movil y crecimiento Tecnologia Fibra en Internet Fija at 12 (2022), https://www.subtel.gob.cl/wp-content/uploads/2022/06/PPT_Series_MARZO_2022_V0.pdf.

[47] Instituto Federal de Telecomunicaciones, *Indicadores por Pais*, https://bit.ift.org.mx/SASVisualAnalyticsViewer/VisualAnalyticsViewer_guest.jsp?reportSBIP=SBIP%3A%2F%2FMETASERVER%2Fshared%20Data%2FSAS%20Visual%20Analytics%2Freportes%2Findicadores%20Internacionales(Report)&page=vi124825&sso_guest=true&informationEnabled=false&commentsEnabled=false&alertsEnabled=false&reportViewOnly=true&reportContextBar=false&shareEnabled=false (last visited Oct. 6, 2022) (the percentage of the population able to access mobile networks can be accessed by clicking on the "Datos por Pais" header, choosing the appropriate country from the dropdown menu, clicking on the "Servicio Movil de Internet" sub header, and reviewing the "Proporcion de población con Cobertura de la Red Movil" table).

[48] *Id.*

[49] For the mobile – 5G analysis, we only present data as of 2021.

U.S. capital cities in the top ten in 2021 included Salt Lake City, Utah (4th – 240.9 Mbps); Austin, Texas (5th – 231.9 Mbps); Lincoln, Nebraska (6th – 230.2 Mbps); Providence, Rhode Island (7th – 229.5 Mbps); and Salem, Oregon (8th – 229.4 Mbps).

29. Figure 17 shows the distribution of fixed broadband download speeds for each country in 2021. The top of each color bar represents the corresponding 25th, 50th, and 75th download speed percentiles.[50] The 25th, 50th, and 75th percentiles of download speeds in the United States were 53.4 Mbps, 129.5 Mbps and 268.7 Mbps, respectively.

30. Figure 18 depicts mean fixed broadband download speeds in G7 countries and South Korea from 2017 to 2021.[51] Following a similar trajectory as other G7 countries, U.S. mean download speed increased from 70.1 Mbps in 2017 to 195.5 Mbps in 2021. South Korea had the fastest mean download speed of these countries in 2021 at 208.0 Mbps.

31. Figure 19 presents a map of mean fixed broadband download speeds by country in 2021.[52] Mean download speeds in 2021 in North America ranged from 50.5 to 195.5 Mbps. The six countries with the highest mean download speeds, including Iceland, Switzerland, South Korea, Denmark, Chile, and Hungary, had a range of download speeds from 200.2 to 253.1 Mbps, whereas the six countries with the lowest mean download speeds, including Turkey, Greece, Mexico, Australia, Estonia, and Czech Republic, had a range of download speeds from 36.5 Mbps to 82.8 Mbps. Western Europe and Scandinavia generally had higher download speeds than Eastern and Southern Europe.

32. Figure 20 presents a map of mean fixed broadband upload speeds by country in 2021.[53] Mean upload speeds in 2021 in North America ranged from 20.2 to 77.6 Mbps. The six countries with the highest mean upload speeds, including Iceland, South Korea, Spain, Japan, Denmark, and France, had a range of download speeds from 141.5 to 250.6 Mbps, whereas the six countries with the lowest mean upload speeds, including Greece, Turkey, Mexico, Belgium, Austria, and Australia, had a range of download speeds from 9.0 to 24.2 Mbps. Scandinavian and Western European countries generally had higher upload speeds than Eastern European Countries.

33. Figure 21 presents a map of mean fixed broadband latency by country in 2021.[54] Mean latency in 2021 was between 18.7 ms and 24.5 ms for North America. Mean latency in 2021 was the lowest in Iceland, Luxembourg, and Denmark, which had latencies ranging from 10.8 ms to 13.0 ms.

34. Figure 22 presents the number of tests in the sample for each country, as well as the number of cities with fixed broadband tests in each country, for the years 2017-2021. Test counts in the United States decreased by 23% from 207.4 million in 2020 to 159.0 million in 2021. The number of cities with fixed broadband tests remained roughly constant in the United States during the five-year time horizon.

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[50] We calculate the country-level mean percentiles from the city-level percentiles using sample counts as weights. Ookla defines a sample as an average across a set of tests from a single user/device for a given geography, time period, platform, and technology. This methodology is employed to prevent any single user/device with a disproportionate number of tests from having an outsized effect on the overall average.

[51] The G7 or Group of Seven is an informal group of industrialized democracies whose leaders meet annually to discuss various issues: Canada, France, Germany, Italy, Japan, the United Kingdom, and the United States. *See* Council on Foreign Relations, *Where Is the G7 Headed?* (June 28, 2022), https://www.cfr.org/backgrounder/g7-and-future-multilateralism.

[52] Each country's mean fixed broadband download speed values are reported in Figure 13. *See infra* Fig. 13.

[53] Each country's mean fixed broadband upload speed values are reported in Figure 14. *See infra* Fig. 14.

[54] Each country's mean fixed broadband latency values are reported in Figure 15. *See infra* Fig. 15.

Fig. 13. Fixed Broadband Mean Download Speed by Country (2017-2021)

Country	2017		2018		2019		2020		2021	
	Rank	Mbps	Rank	Mbps	Rank	Mbps	Rank	Mbps	Rank	Mbps
Australia	33	23.4	33	30.0	33	38.7	33	49.3	33	76.9
Austria	31	32.2	32	37.4	32	43.8	30	64.7	27	102.1
Belgium	18	51.8	21	59.1	23	72.2	25	87.6	25	110.9
Canada	13	60.6	10	81.9	7	114.3	10	136.0	10	173.8
Chile	30	32.8	26	48.9	19	77.2	13	124.6	5	200.9
Czech Republic	28	34.8	29	41.2	31	50.4	32	62.4	31	82.8
Denmark	10	66.4	13	81.0	12	103.3	3	154.5	4	207.3
Estonia	25	42.4	28	41.8	29	55.4	29	66.7	32	78.7
Finland	23	46.4	25	51.5	25	66.0	24	93.5	24	119.8
France	15	56.5	15	79.1	9	114.0	4	151.8	8	197.3
Germany	21	46.9	22	56.0	24	71.1	22	98.0	23	122.1
Greece	36	13.9	35	18.6	35	23.8	35	29.8	35	37.8
Hungary	6	77.0	3	102.3	3	124.3	6	149.6	6	200.2
Iceland	2	124.1	1	153.5	1	164.1	1	208.3	1	253.1
Ireland	20	50.7	20	59.6	20	76.4	23	93.9	22	122.4
Israel	26	40.6	18	62.2	21	76.3	20	105.9	16	155.6
Italy	32	25.5	31	38.3	30	52.2	31	64.7	29	95.6
Japan	7	72.3	11	81.5	13	97.7	15	116.8	12	168.3
Latvia	17	54.4	19	60.1	16	90.6	18	113.8	20	138.7
Lithuania	3	99.6	9	82.2	17	89.5	19	112.4	21	136.3
Luxembourg	16	56.1	14	79.6	10	109.1	12	130.3	13	164.5
Mexico	34	20.6	34	24.2	34	31.5	34	39.8	34	50.5
Netherlands	8	71.0	12	81.4	14	96.4	14	118.2	17	151.5
New Zealand	14	58.5	16	73.3	15	91.1	16	116.6	14	160.5
Norway	11	65.8	8	85.3	11	105.8	11	130.4	15	157.9
Poland	24	45.7	23	54.5	22	76.0	21	102.3	19	140.0
Portugal	19	51.8	17	69.4	18	88.4	17	115.9	18	150.5
Slovakia	27	38.1	27	45.1	27	58.6	26	80.4	28	101.3
Slovenia	29	33.1	30	39.8	28	57.4	27	77.1	26	103.6
South Korea	1	128.5	2	119.8	2	151.6	7	148.2	3	208.0
Spain	12	61.9	7	87.7	8	114.1	9	146.7	7	199.8
Sweden	4	81.6	4	96.9	6	118.4	8	147.3	11	170.1
Switzerland	5	77.4	6	92.1	4	120.6	2	164.8	2	211.7
Turkey	35	16.0	36	18.4	36	22.8	36	26.5	36	36.5
United Kingdom	22	46.6	24	52.6	26	61.0	28	71.3	30	93.2
United States	**9**	**70.1**	**5**	**92.5**	**5**	**119.6**	**5**	**150.5**	**9**	**195.5**

Fig. 14. Fixed Broadband Mean Upload Speed by Country (2017-2021)

Country	2017		2018		2019		2020		2021	
	Rank	Mbps	Rank	Mbps	Rank	Mbps	Rank	Mbps	Rank	Mbps
Australia	32	8.2	31	11.6	30	16.9	31	20.7	31	24.2
Austria	28	9.8	32	11.4	33	14.9	33	17.4	32	23.8
Belgium	26	10.4	29	13.0	32	15.8	32	17.5	33	21.3
Canada	21	18.6	18	30.9	16	46.4	16	60.1	17	77.6
Chile	34	7.1	34	10.1	25	20.5	18	56.0	10	128.3
Czech Republic	20	19.3	21	21.2	23	25.9	23	30.5	25	36.9
Denmark	8	49.0	8	61.1	8	80.1	7	115.8	5	147.6
Estonia	15	27.1	19	28.3	19	40.3	20	51.0	20	60.2
Finland	19	19.9	20	22.0	20	29.0	21	39.4	21	50.3
France	18	24.1	15	37.4	12	66.6	10	105.9	6	141.5
Germany	27	9.8	28	13.5	28	18.6	27	24.8	29	30.7
Greece	36	2.9	36	4.2	36	6.0	36	7.4	36	9.0
Hungary	13	29.6	14	39.7	13	61.4	13	77.3	14	101.0
Iceland	1	129.7	1	160.1	1	169.4	1	215.7	1	250.6
Ireland	22	18.3	22	20.8	21	26.9	24	29.7	27	33.7
Israel	33	7.5	27	13.5	29	16.9	29	22.1	28	32.6
Italy	31	8.4	26	13.8	26	20.1	26	25.8	23	39.8
Japan	4	73.9	3	91.5	2	108.9	3	130.6	4	148.7
Latvia	5	54.3	9	60.5	5	92.2	6	116.5	9	137.9
Lithuania	3	85.7	4	74.4	7	82.7	9	108.1	11	125.5
Luxembourg	12	33.2	11	47.6	11	67.9	12	81.1	13	101.2
Mexico	30	8.9	33	10.3	34	13.2	34	16.5	34	20.2
Netherlands	11	33.4	12	41.3	15	48.6	15	68.7	16	86.9
New Zealand	14	29.2	13	40.1	14	55.2	14	75.2	15	98.3
Norway	7	49.4	7	62.2	9	79.0	11	102.0	12	120.9
Poland	24	14.2	23	17.9	22	26.2	22	35.4	22	47.8
Portugal	17	25.7	16	36.6	18	45.0	19	53.1	19	65.5
Slovakia	23	14.7	24	16.2	24	21.3	25	28.9	26	36.5
Slovenia	25	11.9	25	14.1	27	18.8	28	24.6	24	37.7
South Korea	2	127.9	2	98.4	3	105.1	2	149.0	2	195.5
Spain	10	43.4	5	71.3	4	98.9	4	130.1	3	176.0
Sweden	6	53.3	6	68.3	6	87.9	5	117.7	7	139.6
Switzerland	9	43.8	10	58.0	10	77.1	8	108.7	8	139.5
Turkey	35	3.9	35	5.7	35	7.0	35	7.7	35	11.9
United Kingdom	29	9.7	30	11.9	31	16.5	30	21.1	30	27.2
United States	**16**	**26.9**	**17**	**34.6**	**17**	**46.3**	**17**	**58.1**	**18**	**72.9**

Fig. 15. Fixed Broadband Mean Latency by Country (2017-2021)

Country	2017		2018		2019		2020		2021	
	Rank	ms	Rank	ms	Rank	ms	Rank	ms	Rank	ms
Australia	31	40.0	32	32.3	30	24.7	28	23.1	31	21.5
Austria	26	29.6	27	28.9	28	24.2	18	20.7	22	19.2
Belgium	17	24.8	14	21.4	14	18.3	13	18.8	16	17.2
Canada	21	28.7	19	25.0	18	20.5	20	20.8	20	18.7
Chile	33	40.5	31	31.5	20	22.2	16	19.8	10	15.1
Czech Republic	15	24.0	15	22.4	16	19.4	15	19.2	19	18.6
Denmark	7	19.7	6	18.3	7	15.2	2	13.9	3	13.0
Estonia	8	20.3	17	24.2	12	16.7	10	15.6	12	15.1
Finland	19	27.3	24	27.2	27	24.1	22	21.3	24	19.5
France	32	40.4	35	38.7	34	31.6	32	27.3	34	24.3
Germany	27	29.8	21	26.3	23	23.6	25	22.3	26	20.9
Greece	34	43.8	36	40.4	36	36.8	36	34.0	36	28.5
Hungary	13	22.0	12	20.8	13	17.0	12	16.8	14	15.7
Iceland	1	13.6	1	12.9	2	14.4	7	15.1	1	10.8
Ireland	16	24.7	18	24.7	22	23.3	29	23.4	28	20.9
Israel	14	23.0	10	19.6	15	19.0	17	19.9	17	17.3
Italy	35	43.8	33	35.8	33	29.2	33	27.7	32	23.2
Japan	29	33.6	29	30.8	31	28.1	31	25.8	30	21.5
Latvia	4	18.8	7	18.3	1	14.2	9	15.6	13	15.4
Lithuania	3	17.2	3	17.5	3	14.5	1	13.1	5	13.2
Luxembourg	10	20.6	4	17.5	5	14.5	6	15.0	2	12.6
Mexico	36	44.0	34	38.0	35	32.3	35	29.7	35	24.5
Netherlands	5	19.0	5	18.2	6	15.2	5	14.5	6	14.2
New Zealand	22	28.9	20	25.4	19	21.9	19	20.8	21	18.8
Norway	9	20.4	11	20.0	11	16.6	4	14.2	9	15.1
Poland	20	28.2	23	26.8	26	23.8	24	22.2	23	19.3
Portugal	11	21.2	9	19.4	8	16.0	8	15.4	7	14.4
Slovakia	23	28.9	25	27.5	29	24.3	26	22.6	25	20.4
Slovenia	18	25.8	16	23.8	17	19.5	14	19.1	15	17.1
South Korea	2	15.7	2	15.6	4	14.5	27	22.8	8	14.4
Spain	30	36.3	28	29.4	25	23.7	21	21.0	18	18.4
Sweden	6	19.4	8	19.2	10	16.5	11	16.0	11	15.1
Switzerland	12	22.0	13	21.1	9	16.2	3	14.2	4	13.1
Turkey	28	32.6	30	30.9	32	29.0	34	27.7	33	23.5
United Kingdom	24	29.5	22	26.7	21	22.4	23	22.0	27	20.9
United States	**25**	**29.6**	**26**	**28.4**	**24**	**23.7**	**30**	**23.6**	**29**	**21.3**

Fig. 16. Fixed Broadband Mean Download Speed by Country Capital and U.S. State Capital Cities (2017-2021)

City, Country/State	2017		2018		2019		2020		2021	
	Rank	Mbps	Rank	Mbps	Rank	Mbps	Rank	Mbps	Rank	Mbps
Canberra, Australia	82	28.7	83	36.8	81	53.2	84	46.4	83	71.1
Vienna, Austria	76	39.1	80	41.6	82	51.7	75	86.8	67	138.8
Brussels, Belgium	72	41.7	76	49.3	79	61.4	78	79.4	79	101.0
Ottawa, Canada	36	65.0	20	101.5	8	147.2	24	151.6	43	182.8
Santiago, Chile	80	30.5	78	42.0	72	71.5	54	121.1	35	187.4
Prague, Czech Republic	69	43.4	75	50.1	78	62.6	80	76.8	80	99.4
Copenhagen, Denmark	32	67.6	39	83.1	35	113.1	15	169.5	9	227.3
Tallinn, Estonia	64	48.0	68	57.3	74	70.8	76	83.7	81	98.0
Helsinki, Finland	70	43.3	72	54.8	76	65.8	73	89.5	76	110.3
Paris, France	5	111.9	8	114.7	2	163.6	2	206.4	3	241.3
Berlin, Germany	71	42.8	65	61.2	65	84.2	65	106.6	66	139.4
Athens, Greece	86	14.0	86	18.4	86	23.5	86	28.9	86	37.3
Budapest, Hungary	14	87.4	10	113.8	18	132.3	22	161.7	21	208.4
Reykjavik, Iceland	3	127.2	1	159.1	1	169.5	1	214.7	1	262.0
Dublin, Ireland	46	57.8	63	64.6	63	87.1	66	106.2	68	134.7
Jerusalem, Israel	78	34.8	81	41.0	83	48.6	82	57.1	82	97.8
Rome, Italy	81	28.8	82	37.2	80	56.5	81	75.4	75	116.1
Tokyo, Japan	23	74.5	62	65.0	48	102.5	67	100.3	40	185.0
Riga, Latvia	45	58.2	52	71.5	45	105.1	42	134.4	54	162.0
Vilnius, Lithuania	1	146.5	19	102.3	47	102.7	52	126.0	61	150.3
Luxembourg City, Luxembourg	49	57.0	42	80.6	36	112.4	46	131.6	58	158.1
Mexico City, Mexico	84	26.3	84	32.1	84	40.7	83	47.9	84	61.9
Amsterdam, Netherlands	35	66.7	47	76.2	56	92.0	55	120.9	55	161.6
Wellington, New Zealand	15	83.1	24	97.7	31	118.1	32	146.6	26	199.0
Oslo, Norway	28	71.9	35	87.1	41	107.7	39	138.6	53	163.7
Warsaw, Poland	42	60.1	66	61.1	55	93.9	44	132.6	47	180.0
Lisbon, Portugal	55	52.3	60	65.4	59	90.4	64	109.8	69	134.3
Bratislava, Slovakia	39	63.2	48	73.4	62	88.8	57	115.0	65	139.4
Ljubljana, Slovenia	74	40.8	73	52.5	75	68.4	74	88.8	73	118.9
Seoul, South Korea	2	136.7	4	127.5	7	150.2	31	147.9	19	214.3

City, Country/State	2017		2018		2019		2020		2021	
Madrid, Spain	20	77.0	9	114.5	11	140.8	20	162.9	10	224.9
Stockholm, Sweden	9	96.1	14	111.2	21	130.9	19	163.3	39	185.5
Bern, Switzerland	29	71.6	33	89.0	38	110.8	28	150.9	23	202.5
Ankara, Turkey	85	17.9	85	20.0	85	25.3	85	32.0	85	40.1
London, United Kingdom	68	45.1	74	51.8	77	64.3	79	77.6	77	106.6
Albany, NY	77	38.0	50	71.9	54	96.1	63	111.2	57	160.4
Annapolis, MD	21	76.5	13	111.8	20	131.0	18	164.0	29	195.6
Atlanta, GA	11	89.4	43	79.3	14	138.6	9	173.9	15	217.7
Augusta, ME	79	30.7	71	56.6	69	73.5	71	90.2	74	117.4
Austin, TX	4	115.9	2	136.4	4	154.5	5	184.5	5	231.9
Baton Rouge, LA	38	64.1	44	78.0	39	108.8	35	144.5	37	186.6
Bismarck, ND	27	72.2	22	99.9	28	122.4	37	143.0	46	180.4
Boise, ID	51	56.3	57	67.0	58	91.2	59	114.2	30	194.8
Boston, MA	13	87.6	7	115.8	9	142.8	14	169.6	20	211.6
Carson City, NV	59	50.9	61	65.1	66	83.3	56	115.8	63	144.6
Charleston, WV	52	53.5	32	93.5	42	107.4	50	127.8	50	169.4
Cheyenne, WY	67	45.2	58	66.6	61	90.1	68	99.8	71	127.6
Columbia, SC	73	41.3	69	57.2	60	90.2	60	112.1	59	157.7
Columbus, OH	57	51.3	54	69.3	51	98.4	49	129.2	45	181.4
Concord, NH	22	75.4	15	110.0	24	129.8	21	162.6	18	215.4
Denver, CO	30	71.6	34	88.9	37	111.7	23	153.0	36	187.3
Des Moines, IA	50	56.5	56	68.1	57	92.0	62	111.4	52	164.0
Dover, DE	10	93.0	6	120.5	3	155.7	4	189.8	2	243.6
Frankfort, KY	83	27.8	77	43.5	71	72.8	77	81.6	78	101.2
Harrisburg, PA	33	67.2	21	100.6	32	117.5	33	146.6	48	179.9
Hartford, CT	56	51.4	49	72.3	50	98.6	43	134.2	28	196.6
Helena, MT	75	39.8	59	65.9	68	77.0	69	97.2	70	131.3
Honolulu, HI	25	73.6	25	97.7	26	126.7	27	151.0	33	188.5
Indianapolis, IN	37	64.3	38	83.7	27	123.1	30	149.0	24	201.3
Jackson, MS	48	57.1	40	82.7	52	97.9	61	111.8	62	148.5
Jefferson City, MO	62	49.3	67	60.9	70	72.9	72	89.6	72	126.3
Juneau, AK	66	45.6	70	56.7	67	80.0	41	135.2	32	190.1

City, Country/State	2017		2018		2019		2020		2021	
Lansing, MI	26	73.1	26	96.9	25	127.5	34	145.7	22	205.0
Lincoln, NE	44	59.2	16	109.4	6	151.1	3	191.7	6	230.2
Little Rock, AR	61	49.9	53	69.7	53	97.7	48	129.8	44	182.4
Madison, WI	60	50.8	36	86.3	34	113.2	38	138.6	41	184.9
Montgomery, AL	54	52.3	45	76.8	46	104.3	53	121.7	56	161.5
Montpelier, VT	65	46.7	79	42.0	73	71.1	70	94.9	60	155.9
Nashville, TN	12	88.4	18	108.0	15	138.1	10	173.0	14	218.3
Oklahoma City, OK	18	79.6	31	93.6	16	135.7	11	172.4	11	222.6
Olympia, WA	19	78.5	12	112.4	17	133.0	13	170.1	13	219.8
Phoenix, AZ	31	71.4	29	94.2	29	120.8	36	143.5	34	187.9
Pierre, SD	40	61.4	37	84.2	44	105.2	47	130.1	64	141.4
Providence, RI	41	60.7	27	95.1	23	129.9	12	172.0	7	229.5
Raleigh, NC	8	99.8	3	127.9	5	153.3	7	177.8	12	222.5
Richmond, VA	24	73.8	23	99.0	22	130.1	25	151.5	27	197.5
Sacramento, CA	34	67.1	30	94.1	19	131.2	17	165.1	16	216.2
Saint Paul, MN	43	59.5	41	80.7	43	106.7	58	114.3	49	170.2
Salem, OR	17	79.8	17	109.2	12	140.4	8	177.3	8	229.4
Salt Lake City, UT	6	109.6	5	120.7	10	141.5	6	181.5	4	240.9
Santa Fe, NM	47	57.8	55	68.5	64	85.9	51	126.1	51	169.0
Springfield, IL	53	52.9	64	62.0	33	115.6	26	151.1	25	200.0
Tallahassee, FL	63	48.7	46	76.7	40	108.8	40	137.3	31	190.2
Topeka, KS	58	51.0	51	71.6	49	101.6	45	132.6	42	184.2
Trenton, NJ	7	102.1	11	112.7	13	140.1	16	165.3	17	215.9
Washington, DC	16	80.8	28	94.9	30	119.6	29	149.4	38	185.9

Fig. 17. Fixed Broadband Download Speed Percentiles (2021)

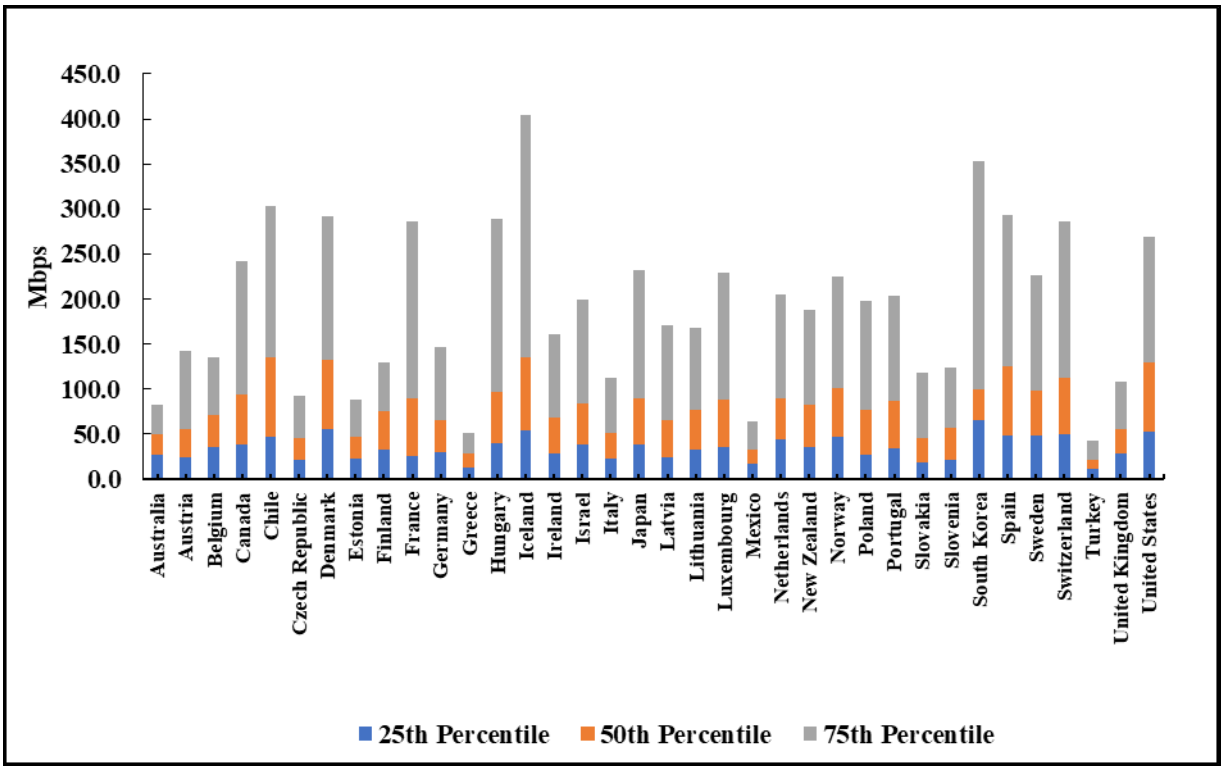


Fig. 18. Fixed Broadband Mean Download Speed for G7 Countries and South Korea (2017-2021)

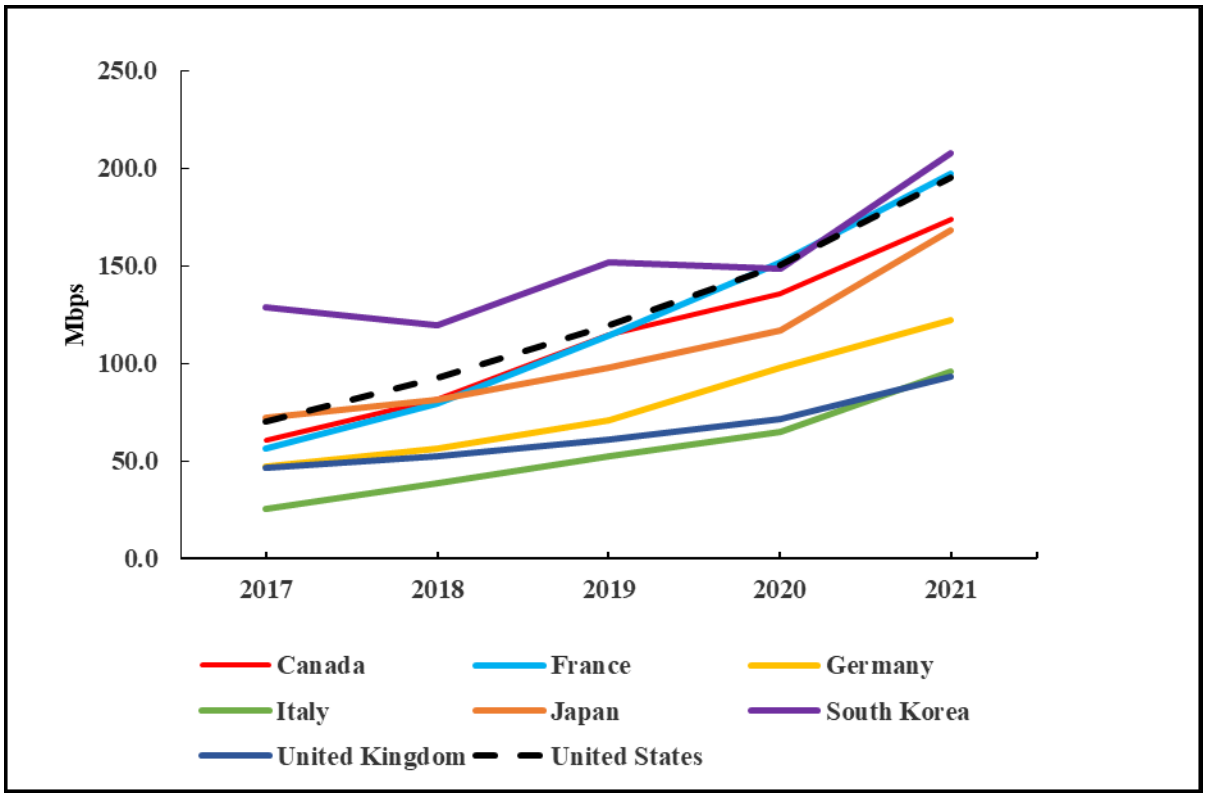


Fig. 19. Fixed Broadband Mean Download Speed by Country (2021)

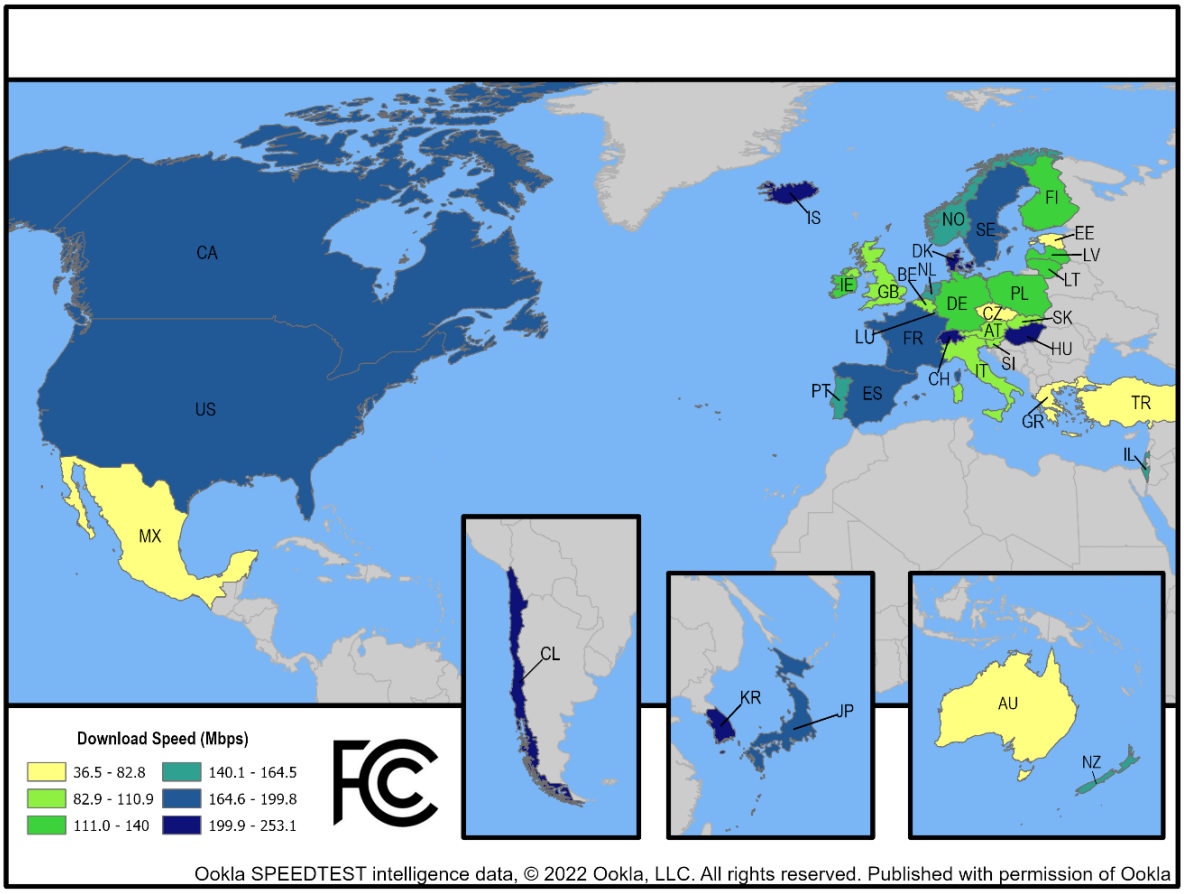


Fig. 20. Fixed Broadband Mean Upload Speed by Country (2021)

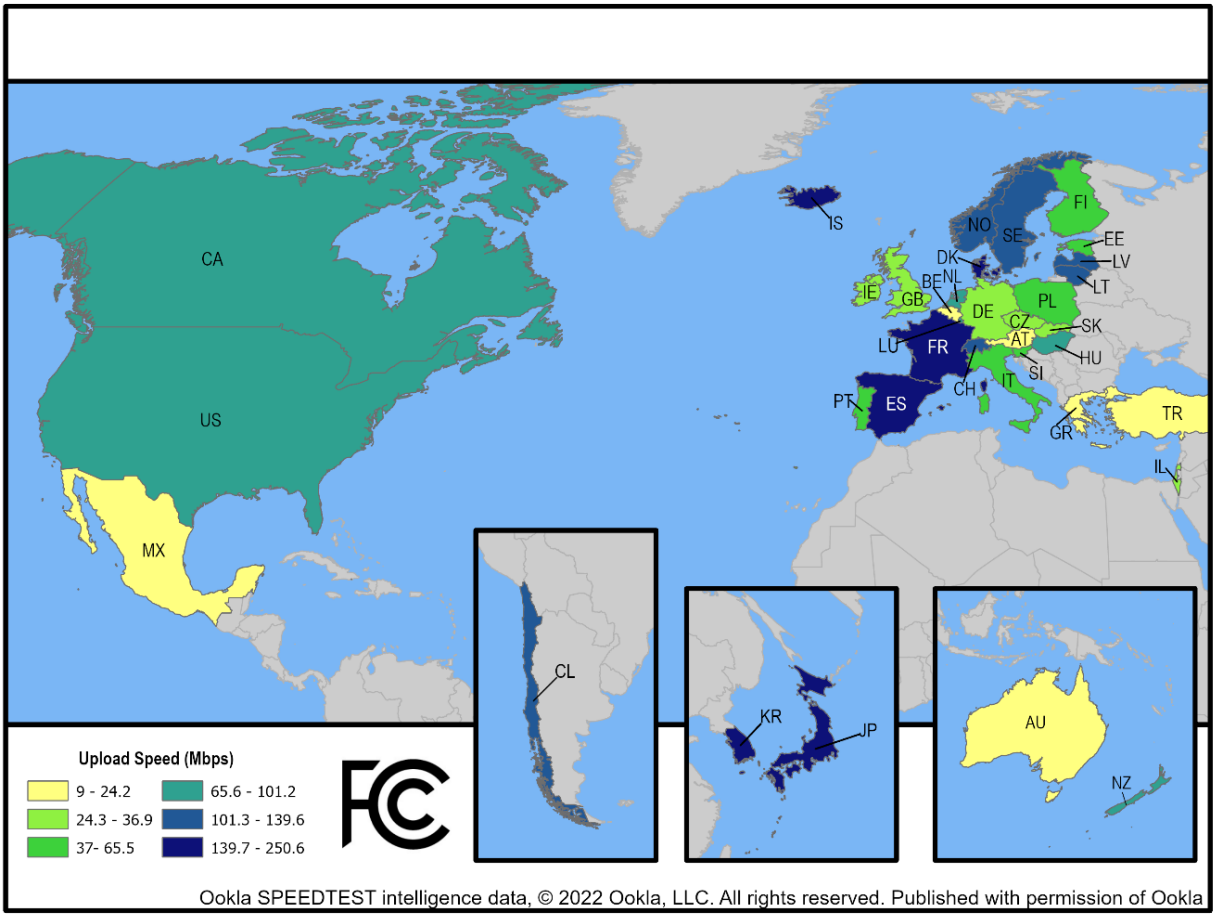


Fig. 21. Fixed Broadband Mean Latency by Country (2021)

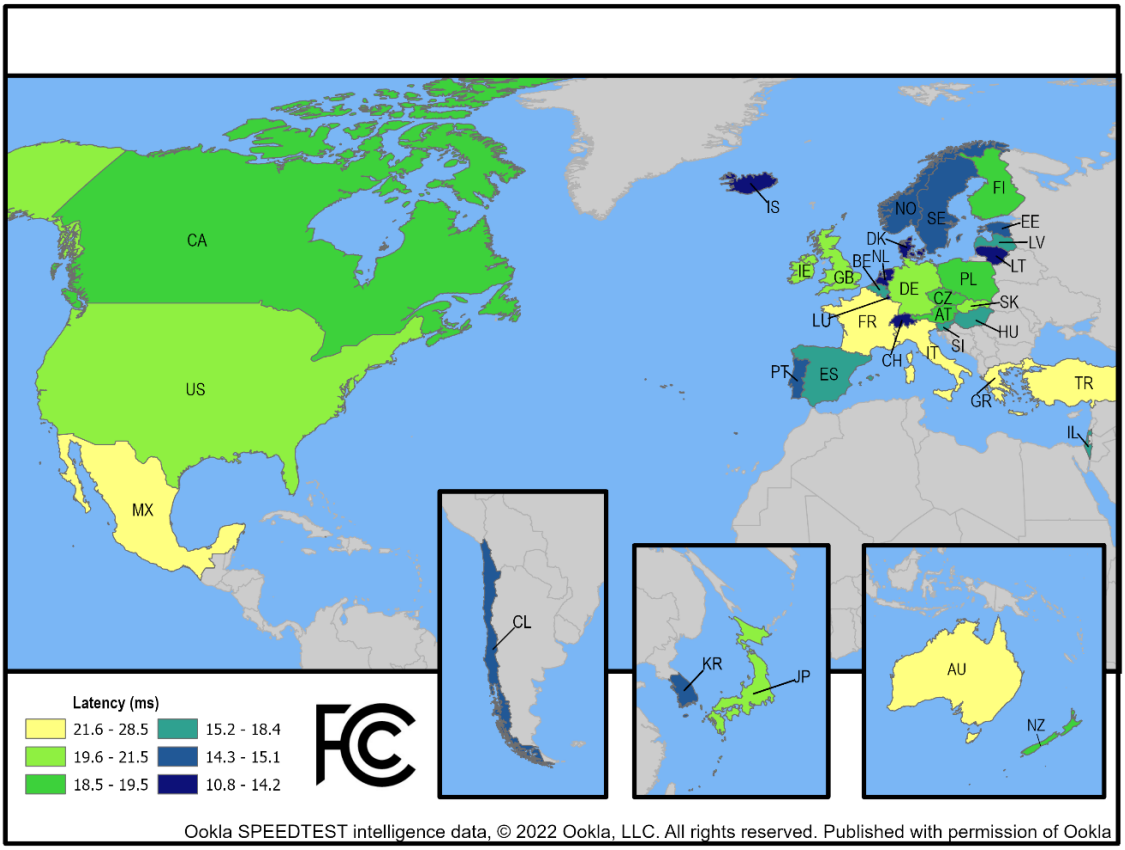


Fig. 22. Fixed Broadband City Count and Test Count by Country (2017-2021)

Country	Test Count (1000s)					City Count				
	2017	2018	2019	2020	2021	2017	2018	2019	2020	2021
Australia	31,912	28,426	27,127	25,689	20,673	9,648	10,939	13,246	9,775	10,000
Austria	6,234	6,267	4,732	4,824	4,381	1,413	1,417	1,422	2,260	2,265
Belgium	5,940	4,996	4,814	6,135	5,637	606	608	612	603	607
Canada	31,334	30,081	29,883	35,078	30,620	2,830	2,895	3,225	3,246	3,287
Chile	9,458	9,558	7,902	13,786	12,114	231	260	267	1,070	1,518
Czech Republic	5,140	5,267	4,870	5,170	4,940	5,941	5,984	5,955	5,897	5,884
Denmark	5,080	5,160	5,012	5,989	5,246	586	587	634	638	635
Estonia	996	1,359	1,163	1,126	981	1,893	3,514	3,629	3,319	3,374
Finland	3,967	4,170	3,989	3,421	3,362	83	83	330	1,361	2,189
France	25,845	23,568	21,586	26,725	26,133	35,131	35,104	35,309	34,422	33,996
Germany	37,897	37,737	37,640	43,713	40,624	11,632	11,617	11,642	11,563	11,591
Greece	6,924	7,761	7,984	10,154	10,092	6,233	6,878	7,775	7,668	7,709
Hungary	7,398	7,954	7,306	8,144	7,120	3,070	3,095	3,113	3,104	3,087
Iceland	274	276	235	232	183	99	95	106	106	103
Ireland	2,394	2,517	2,657	3,393	2,583	163	160	159	159	159
Israel	4,320	5,437	5,056	8,183	6,792	1,007	1,003	1,045	1,051	1,051
Italy	57,872	54,093	43,095	45,307	37,296	40,378	40,801	40,126	39,918	39,940
Japan	16,314	15,445	14,063	14,431	13,839	1,965	2,010	1,905	1,764	1,761
Latvia	1,260	1,121	1,093	1,231	1,408	1,257	1,229	1,305	1,260	1,318
Lithuania	1,586	1,418	1,303	1,438	1,420	2,722	2,854	2,760	2,501	2,581
Luxembourg	505	547	447	489	457	427	434	431	428	357
Mexico	39,054	42,458	44,245	64,283	51,291	9,083	10,138	11,034	13,846	14,478
Netherlands	17,843	15,760	15,106	16,517	14,789	2,458	2,457	2,458	2,457	2,455
New Zealand	4,460	3,994	3,551	3,044	2,973	2,223	2,252	2,268	2,236	2,200
Norway	3,486	3,447	3,212	3,449	2,692	741	755	1,941	2,193	2,195
Poland	13,248	12,608	12,537	14,648	11,969	3,995	4,015	9,734	14,692	14,424
Portugal	7,116	7,946	7,804	9,000	7,760	1,180	1,180	1,353	1,530	1,546

Country	Test Count (1000s)					City Count				
	2017	2018	2019	2020	2021	2017	2018	2019	2020	2021
Slovakia	2,941	3,244	3,464	3,684	3,655	2,780	2,797	2,806	2,805	2,814
Slovenia	1,682	1,720	1,813	2,204	1,853	5,526	5,489	5,553	5,487	5,511
South Korea	2,686	2,971	3,062	2,891	3,053	161	162	162	162	162
Spain	15,392	14,399	12,943	12,609	10,799	13,739	14,201	14,169	13,930	14,039
Sweden	1,834	1,725	1,921	2,331	2,288	414	444	507	555	570
Switzerland	4,884	5,395	5,228	6,077	5,646	2,584	2,579	2,593	2,557	2,544
Turkey	12,025	14,058	13,806	19,348	17,338	4,500	4,652	4,767	8,923	9,267
United Kingdom	47,236	53,479	51,881	62,628	55,331	6,417	6,511	6,624	11,323	11,305
United States	**174,228**	**179,304**	**171,306**	**207,452**	**159,066**	**27,000**	**27,433**	**27,952**	**27,744**	**27,773**

B. Mobile Broadband – 4G LTE Results

35. Figure 23 compares mean 4G LTE download speeds by country, for the years 2017-2021. For mean download speeds, the United States ranked 23rd among the 36 countries in 2021, with a mean download speed of 44.8 Mbps, increasing from 24.4 Mbps with a ranking of 34th in 2017. In 2021, Norway had the highest mean download speed at 92.1 Mbps, whereas Chile had the lowest mean download speed at 20.4 Mbps.

36. Figure 24 compares mean 4G LTE upload speeds by country, for the years 2017-2021. For mean upload speeds, the United States ranked 36th among the 36 countries in 2021, with the speeds slightly decreasing from 10.5 Mbps in 2020 to 9.9 Mbps in 2021. Iceland, the country with the fastest mean upload speed in each of the past five years, had a mean upload speed of 19.0 Mbps in 2021—a slight decrease from 20.0 Mbps in 2020.

37. Figure 25 compares mean 4G LTE latency by country, for the years 2017-2021. For mean latency, the United States ranked 34th among the 36 countries in 2021, with a mean latency of 41.5 ms. Iceland ranked 1st in 2021 with a mean latency of 20.6 ms.

38. Figure 26 compares mean 4G LTE download speeds by country and U.S. state capital cities, for the years 2017-2021. The mean download speed in Washington D.C. in 2021 was 58.4 Mbps, which ranked 20th among the 86 country and state capital cities. The highest ranked U.S. state capital city in 2021 was Harrisburg, Pennsylvania, which ranked 9th with a mean download speed of 65.7 Mbps. No other U.S. state capitals were among the top ten ranked capital cities.

39. Figure 27 shows the distribution of 4G LTE download speeds for each country in 2021. The top of each color bar represents the corresponding 25th, 50th, and 75th download speed percentiles.[55] The 25th, 50th and 75th percentiles for download speeds in the United States were 12.9 Mbps, 31.3 Mbps, and 62.0 Mbps, respectively.

40. Figure 28 shows that mean 4G LTE download speed in the United States modestly increased at a similar pace as that in other G7 countries during the past few years. Canada experienced the fastest growth in mean download speed over the last five years, increasing from 44.8 Mbps in 2017 to 79.0 Mbps in 2021.

41. Figure 29 presents a map of mean 4G LTE download speeds by country in 2021.[56] Mean download speeds in 2021 in North America ranged from 33.2 Mbps to 79.0 Mbps. The six countries with the highest mean download speeds, including Norway, Iceland, the Netherlands, Canada, South Korea, and Denmark, had a range of download speeds from 65.7 Mbps to 92.1 Mbps. The six countries with the lowest mean download speeds, including Chile, Israel, Mexico, Japan, United Kingdom, and Spain, had a range from 20.4 Mbps to 39.0 Mbps. All Scandinavian countries were in the top ten countries in terms of download speeds.

42. Figure 30 presents a map of mean 4G LTE upload speeds by country in 2021.[57] Mean upload speeds in 2021 in North America ranged from 9.9 Mbps to 14.3 Mbps. The six countries with the highest mean upload speeds, including Iceland, Switzerland, Norway, Denmark, Turkey, and the Netherlands, had a range of upload speeds from 16.2 Mbps to 19.0 Mbps, whereas the six countries with the lowest mean upload speeds, including the United States, United Kingdom, France, Japan, Slovakia, and Poland, had a range from 9.9 Mbps to 11.1 Mbps.

[55] We calculate the country-level mean percentiles by taking the weighted average of the city-level percentiles using sample counts as weights.

[56] Each country's mean 4G LTE download speed values are reported in Figure 23. *See infra* Fig. 23.

[57] Each country's mean 4G LTE upload speed values are reported in Figure 24. *See infra* Fig. 24.

43. Figure 31 presents a map of mean 4G LTE latency by country in 2021.[58] Mean latency in 2021 was between 31.7 ms and 45.1 ms for North American countries. The lowest mean latency was concentrated in Eastern European countries, such as Hungary, Latvia, Slovakia, and Slovenia.

44. Figure 32 presents the number of tests in the sample for each country, as well as the number of cities with 4G LTE tests in each country, for the years 2017-2021. Test counts in the United States decreased by 45% from 13.1 million in 2020 to 7.2 million in 2021. The number of cities with tests in the United States decreased by about 500 cities during the same period. These changes are most likely due to an increasing number of consumers testing on 5G networks instead of 4G LTE networks.

[58] Each country's mean 4G LTE latency values are reported in Figure 25. *See infra* Fig. 25.

Fig. 23. Mobile Broadband – 4G LTE Mean Download Speed by Country (2017-2021)

Country	2017		2018		2019		2020		2021	
	Rank	Mbps	Rank	Mbps	Rank	Mbps	Rank	Mbps	Rank	Mbps
Australia	5	48.5	4	56.3	5	62.7	6	57.8	9	62.2
Austria	18	36.5	19	39.0	17	45.6	12	51.5	16	53.2
Belgium	11	40.7	7	50.4	10	50.3	11	52.4	12	57.5
Canada	6	44.8	3	59.2	3	71.3	2	77.5	4	79.0
Chile	36	20.9	36	20.0	36	21.2	36	20.8	36	20.4
Czech Republic	21	32.8	15	42.8	16	46.4	18	45.7	22	46.3
Denmark	9	42.2	11	46.9	11	49.4	10	53.4	6	65.7
Estonia	24	31.6	22	35.8	19	44.2	17	46.6	14	54.3
Finland	19	36.3	17	41.8	14	47.5	15	49.5	10	60.0
France	22	32.0	20	38.5	15	46.8	16	48.7	15	54.0
Germany	28	30.0	26	33.3	27	35.7	24	37.8	20	48.5
Greece	14	39.8	14	43.1	18	44.2	22	40.1	17	52.5
Hungary	3	50.5	8	50.2	20	43.2	20	41.2	27	40.9
Iceland	4	49.7	2	69.3	1	78.6	1	80.2	2	85.9
Ireland	25	31.0	29	30.5	32	31.7	33	33.1	28	40.7
Israel	31	26.3	33	26.9	34	27.8	35	24.9	35	30.6
Italy	17	37.6	23	35.3	26	36.6	25	37.8	26	42.1
Japan	35	22.1	34	26.7	33	31.7	30	35.0	33	36.7
Latvia	26	30.9	28	31.8	29	34.3	31	35.0	30	40.4
Lithuania	15	38.6	16	42.7	13	48.3	13	51.5	13	57.3
Luxembourg	10	41.5	9	47.6	12	48.4	14	50.9	11	59.2
Mexico	33	25.0	35	25.2	35	27.4	34	32.1	34	33.2
Netherlands	2	51.7	5	55.7	6	61.2	4	72.7	3	82.8
New Zealand	7	44.6	6	51.6	9	52.0	9	53.5	18	50.5
Norway	1	63.1	1	71.8	2	74.5	3	75.4	1	92.1
Poland	32	25.4	32	28.9	28	35.4	28	37.1	21	46.7
Portugal	30	29.4	25	33.5	23	37.7	21	40.6	19	48.7
Slovakia	23	31.6	27	33.3	30	34.2	26	37.3	29	40.4
Slovenia	27	30.1	24	34.5	22	38.5	23	39.9	24	43.2
South Korea	8	43.4	13	44.5	4	63.2	5	64.3	5	68.1
Spain	16	37.7	21	38.2	24	37.4	29	35.6	31	39.0
Sweden	12	40.5	10	46.9	7	54.3	7	55.2	7	64.5
Switzerland	20	35.7	12	46.3	8	52.1	8	53.8	8	62.7
Turkey	13	40.0	18	39.7	21	38.6	27	37.1	25	42.5
United Kingdom	29	29.6	31	29.5	31	33.4	32	33.4	32	36.8
United States	**34**	**24.4**	**30**	**30.4**	**25**	**37.0**	**19**	**42.9**	**23**	**44.8**

Fig. 24. Mobile Broadband – 4G LTE Mean Upload Speed by Country (2017-2021)

Country	2017		2018		2019		2020		2021	
	Rank	Mbps	Rank	Mbps	Rank	Mbps	Rank	Mbps	Rank	Mbps
Australia	10	15.8	10	16.0	7	16.9	21	13.6	26	12.7
Austria	21	14.1	18	14.4	17	15.3	11	15.0	12	14.5
Belgium	11	15.8	6	16.8	8	16.6	9	15.3	11	14.8
Canada	24	13.1	21	14.0	15	15.9	19	13.7	25	12.8
Chile	31	11.4	32	11.5	25	13.8	20	13.6	22	13.4
Czech Republic	14	14.9	8	16.4	6	17.0	7	15.7	8	15.4
Denmark	3	18.6	2	20.0	3	19.9	4	18.1	4	17.1
Estonia	30	11.6	26	12.6	24	13.8	23	13.4	21	13.4
Finland	12	15.7	11	15.8	10	16.3	10	15.2	7	16.0
France	34	10.3	33	10.6	33	11.4	33	10.6	34	10.5
Germany	29	11.7	27	12.5	27	13.3	29	11.8	29	11.9
Greece	22	14.0	20	14.1	19	15.1	17	14.3	9	15.3
Hungary	4	18.1	4	17.9	14	16.1	12	14.6	16	14.1
Iceland	1	21.5	1	23.0	1	22.6	1	20.0	1	19.0
Ireland	18	14.4	24	13.1	28	13.3	26	12.5	19	13.6
Israel	7	16.3	5	16.9	9	16.3	22	13.5	23	13.0
Italy	20	14.2	22	13.9	22	14.4	27	12.5	27	12.6
Japan	36	8.5	36	9.1	36	9.8	32	11.1	33	10.7
Latvia	23	13.3	25	13.1	29	12.9	30	11.6	30	11.6
Lithuania	17	14.4	17	14.9	21	14.9	18	13.8	17	13.9
Luxembourg	13	15.2	14	15.3	12	16.1	16	14.3	15	14.2
Mexico	8	16.0	19	14.2	23	14.0	14	14.4	14	14.3
Netherlands	9	15.9	13	15.6	13	16.1	5	16.0	6	16.2
New Zealand	6	16.3	12	15.7	11	16.3	8	15.6	13	14.5
Norway	2	19.6	3	19.7	2	20.3	3	18.6	3	18.6
Poland	33	10.6	34	10.4	34	11.3	36	10.3	31	11.1
Portugal	27	12.6	28	12.4	26	13.5	25	12.6	20	13.5
Slovakia	28	12.0	30	12.1	31	12.5	31	11.6	32	10.9
Slovenia	32	11.0	29	12.2	30	12.8	28	11.9	28	12.1
South Korea	19	14.4	15	15.2	16	15.7	15	14.4	18	13.7
Spain	16	14.7	16	15.1	20	15.0	24	13.2	24	13.0
Sweden	26	12.6	23	13.2	18	15.1	13	14.6	10	15.2
Switzerland	15	14.9	7	16.8	4	19.5	2	19.1	2	18.6
Turkey	5	16.8	9	16.3	5	17.1	6	15.9	5	16.7
United Kingdom	25	13.0	31	12.0	32	12.2	35	10.3	35	9.9
United States	**35**	**9.0**	**35**	**9.7**	**35**	**11.1**	**34**	**10.5**	**36**	**9.9**

Fig. 25. Mobile Broadband – 4G LTE Mean Latency by Country (2017-2021)

Country	2017		2018		2019		2020		2021	
	Rank	ms	Rank	ms	Rank	ms	Rank	ms	Rank	ms
Australia	11	29.3	13	28.2	17	29.6	20	30.4	21	29.6
Austria	10	28.8	11	27.3	12	27.4	7	25.9	8	25.4
Belgium	8	27.6	9	27.0	18	29.7	13	27.5	16	29.1
Canada	28	38.8	27	35.9	23	34.1	24	32.7	24	31.7
Chile	23	34.6	24	34.2	22	33.9	26	35.6	26	32.7
Czech Republic	13	29.5	8	26.7	8	26.4	16	28.5	18	29.3
Denmark	5	24.8	6	25.6	10	27.1	11	26.7	7	24.7
Estonia	6	25.3	5	24.2	4	24.9	8	26.0	13	27.5
Finland	7	26.7	7	25.7	5	25.3	5	24.9	3	22.9
France	31	40.9	30	41.3	30	41.5	29	37.5	29	36.5
Germany	32	41.7	28	38.1	28	38.2	27	37.1	27	33.2
Greece	21	32.0	12	27.3	11	27.4	12	26.8	10	26.1
Hungary	3	24.0	4	24.0	6	25.3	4	24.7	6	24.1
Iceland	4	24.4	1	21.0	1	21.1	1	20.3	1	20.6
Ireland	20	32.0	22	33.5	24	34.3	23	31.5	19	29.3
Israel	14	30.4	18	29.5	15	29.1	21	30.5	15	28.0
Italy	27	38.4	35	49.7	33	45.3	31	40.9	33	40.5
Japan	35	56.2	36	53.0	36	54.0	36	45.6	35	42.9
Latvia	1	21.3	2	22.5	2	23.4	3	23.9	4	23.5
Lithuania	9	28.3	10	27.2	7	26.3	6	25.9	12	27.3
Luxembourg	18	31.2	15	28.5	9	26.5	10	26.1	9	26.0
Mexico	36	60.1	34	49.2	35	50.0	34	41.9	36	45.1
Netherlands	12	29.4	17	29.1	20	31.0	18	29.2	14	27.6
New Zealand	26	38.1	29	39.3	29	39.4	28	37.2	30	36.6
Norway	24	34.7	26	35.4	27	37.6	25	34.0	28	33.2
Poland	25	35.6	23	33.9	25	34.5	22	31.3	23	30.3
Portugal	15	30.6	16	28.7	16	29.5	17	29.2	20	29.5
Slovakia	17	30.9	20	31.9	21	31.1	9	26.0	5	23.6
Slovenia	2	23.6	3	23.0	3	24.5	2	23.5	2	22.2
South Korea	29	39.3	25	34.5	26	35.4	30	38.3	25	32.1
Spain	33	47.5	32	45.3	32	43.6	32	41.1	31	39.3
Sweden	22	33.4	21	32.8	19	30.9	19	30.2	17	29.1
Switzerland	19	31.5	19	29.5	13	28.9	14	27.6	11	26.8
Turkey	16	30.6	14	28.4	14	29.0	15	27.8	22	29.9
United Kingdom	30	39.8	31	41.4	31	42.0	33	41.6	32	40.4
United States	**34**	**50.4**	**33**	**46.4**	**34**	**46.7**	**35**	**44.1**	**34**	**41.5**

Fig. 26. Mobile Broadband – 4G LTE Mean Download Speed by Country Capital and U.S. State Capital Cities (2017-2021)

City, Country/State	2017		2018		2019		2020		2021	
	Rank	Mbps	Rank	Mbps	Rank	Mbps	Rank	Mbps	Rank	Mbps
Canberra, Australia	7	43.6	11	49.2	4	65.7	9	61.7	7	70.9
Vienna, Austria	21	37.1	28	38.2	29	44.0	28	49.6	31	51.6
Brussels, Belgium	14	39.7	8	49.7	14	49.7	11	57.6	12	63.4
Ottawa, Canada	16	39.4	3	56.0	3	65.9	3	70.7	5	73.0
Santiago, Chile	68	20.0	84	18.9	86	20.2	86	19.2	86	18.7
Prague, Czech Republic	6	43.9	4	55.0	9	55.6	15	54.5	24	54.5
Copenhagen, Denmark	13	41.0	12	47.2	11	51.3	16	54.2	8	67.1
Tallinn, Estonia	25	34.8	26	39.6	20	48.5	24	51.3	16	60.3
Helsinki, Finland	18	38.0	16	44.4	18	49.0	26	50.6	11	64.4
Paris, France	27	33.0	21	41.1	15	49.3	19	53.1	21	57.3
Berlin, Germany	32	30.6	29	37.3	26	44.9	31	46.5	25	54.3
Athens, Greece	15	39.7	19	41.4	30	42.6	64	38.2	33	50.9
Budapest, Hungary	2	53.9	5	54.3	23	46.5	39	44.8	50	44.8
Reykjavik, Iceland	4	48.6	2	71.1	1	82.2	2	79.9	2	86.9
Dublin, Ireland	31	31.0	49	30.2	65	31.8	76	33.0	68	39.8
Jerusalem, Israel	48	25.3	48	30.2	81	24.2	85	21.2	85	27.2
Rome, Italy	19	37.3	36	34.8	52	36.7	65	36.7	72	38.9
Tokyo, Japan	55	23.2	60	27.0	73	29.1	71	34.7	78	35.0
Riga, Latvia	28	33.0	41	33.0	60	35.0	68	35.6	66	40.2
Vilnius, Lithuania	8	43.3	15	44.8	17	49.2	18	53.4	17	59.4
Luxembourg City, Luxembourg	11	42.6	10	49.3	22	47.1	14	54.9	14	61.4
Mexico City, Mexico	58	23.0	72	24.5	78	27.3	80	31.9	81	33.4
Amsterdam, Netherlands	3	50.7	7	53.5	6	58.0	4	69.2	3	81.9
Wellington, New Zealand	5	44.9	6	53.9	13	50.2	17	53.7	32	51.4
Oslo, Norway	1	64.6	1	72.2	2	74.2	1	80.3	1	97.2
Warsaw, Poland	39	27.9	47	30.4	54	36.5	63	38.3	41	47.0
Lisbon, Portugal	23	35.6	25	39.7	31	42.1	40	44.8	26	54.1
Bratislava, Slovakia	20	37.1	22	40.3	34	42.1	32	46.4	30	52.1
Ljubljana, Slovenia	22	36.3	23	40.2	43	38.2	62	38.6	60	43.0

City, Country/State	2017		2018		2019		2020		2021	
Seoul, South Korea	12	42.3	17	43.7	5	63.3	5	67.5	6	71.6
Madrid, Spain	9	43.1	18	42.7	32	42.1	55	40.6	56	43.7
Stockholm, Sweden	10	42.9	9	49.5	7	57.7	8	62.3	4	78.9
Bern, Switzerland	24	35.6	13	45.4	10	52.8	12	55.8	10	64.9
Ankara, Turkey	17	39.4	24	39.7	50	37.1	67	35.9	62	42.7
London, United Kingdom	40	27.8	55	28.5	51	37.1	50	41.6	43	46.4
Albany, NY	64	21.0	64	26.6	61	34.6	51	41.6	48	45.4
Annapolis, MD	29	32.0	14	44.9	8	55.6	6	66.9	15	61.0
Atlanta, GA	38	28.3	32	35.9	21	48.4	29	49.0	36	49.7
Augusta, ME	78	17.8	78	22.1	79	26.1	83	29.7	71	39.2
Austin, TX	47	25.3	46	31.0	56	36.0	53	40.8	65	40.6
Baton Rouge, LA	59	22.5	58	28.2	57	35.8	38	45.1	51	44.6
Bismarck, ND	30	31.1	68	25.4	55	36.1	30	47.2	34	50.5
Boise, ID	69	20.0	44	31.4	41	38.7	47	42.8	46	45.9
Boston, MA	51	24.5	45	31.2	35	41.7	27	50.4	23	55.1
Carson City, NV	83	16.6	86	17.8	84	21.5	82	29.7	77	36.2
Charleston, WV	81	16.8	66	25.9	62	34.6	37	45.4	57	43.7
Cheyenne, WY	85	15.0	83	19.3	71	29.5	66	36.7	83	31.9
Columbia, SC	63	21.1	57	28.4	63	33.6	58	40.1	73	37.8
Columbus, OH	42	25.8	35	34.9	27	44.7	25	51.3	27	53.7
Concord, NH	82	16.8	82	19.8	83	23.3	75	33.5	75	36.7
Denver, CO	65	20.9	51	29.3	48	37.2	43	44.4	54	44.3
Des Moines, IA	53	23.7	71	24.7	74	29.1	74	33.8	64	40.6
Dover, DE	36	28.7	27	38.8	16	49.2	7	63.8	22	57.1
Frankfort, KY	66	20.4	65	26.5	38	40.2	41	44.6	42	46.9
Harrisburg, PA	54	23.6	33	35.7	28	44.6	10	58.4	9	65.7
Hartford, CT	57	23.1	43	31.7	53	36.6	46	43.9	35	49.7
Helena, MT	72	19.4	73	24.4	46	37.7	52	40.8	52	44.6
Honolulu, HI	71	19.8	67	25.5	67	31.4	60	39.4	67	40.2
Indianapolis, IN	35	29.1	37	34.6	36	40.9	44	44.4	39	48.4
Jackson, MS	80	17.0	76	23.1	80	24.6	84	27.6	84	29.2
Jefferson City, MO	75	18.4	77	22.3	68	30.9	78	32.9	80	33.6

City, Country/State	2017		2018		2019		2020		2021	
Juneau, AK	77	18.3	85	17.9	85	21.2	69	34.9	76	36.6
Lansing, MI	34	30.2	31	36.7	39	39.0	33	46.3	29	52.9
Lincoln, NE	56	23.1	70	24.8	72	29.2	61	38.8	79	34.8
Little Rock, AR	41	26.9	34	35.4	33	42.1	36	45.9	37	48.6
Madison, WI	76	18.3	80	20.2	82	24.0	77	33.0	74	37.5
Montgomery, AL	37	28.3	52	29.1	64	31.9	57	40.4	70	39.6
Montpelier, VT	79	17.4	69	25.2	76	28.9	73	34.0	53	44.5
Nashville, TN	61	22.1	54	29.0	45	38.1	48	42.7	49	45.3
Oklahoma City, OK	73	19.3	75	23.3	77	27.4	79	32.6	63	41.4
Olympia, WA	74	19.2	74	24.2	69	30.4	59	39.6	69	39.7
Phoenix, AZ	62	21.2	63	26.8	42	38.7	35	46.0	44	46.4
Pierre, SD	43	25.7	62	26.8	58	35.8	81	30.8	28	53.0
Providence, RI	46	25.5	40	33.3	12	51.1	21	52.2	19	58.5
Raleigh, NC	50	24.6	50	29.5	47	37.4	45	44.0	38	48.4
Richmond, VA	52	24.4	42	32.2	40	38.9	49	42.5	47	45.5
Sacramento, CA	60	22.4	59	28.0	59	35.5	56	40.5	61	42.7
Saint Paul, MN	26	34.5	20	41.1	19	48.7	20	52.6	18	59.1
Salem, OR	33	30.4	30	37.0	37	40.9	42	44.5	55	44.0
Salt Lake City, UT	70	19.9	61	26.9	44	38.2	23	51.4	13	62.4
Santa Fe, NM	86	14.6	81	20.0	66	31.6	70	34.8	58	43.6
Springfield, IL	44	25.6	53	29.1	49	37.1	34	46.0	59	43.5
Tallahassee, FL	45	25.6	39	33.5	24	45.5	22	51.8	40	47.2
Topeka, KS	67	20.4	56	28.5	70	30.1	72	34.4	82	33.1
Trenton, NJ	84	16.4	79	21.8	75	29.0	54	40.7	45	46.3
Washington, DC	49	24.8	38	34.0	25	44.9	13	55.1	20	58.4

Fig. 27. Mobile Broadband – 4G LTE Download Speed Percentiles (2021)

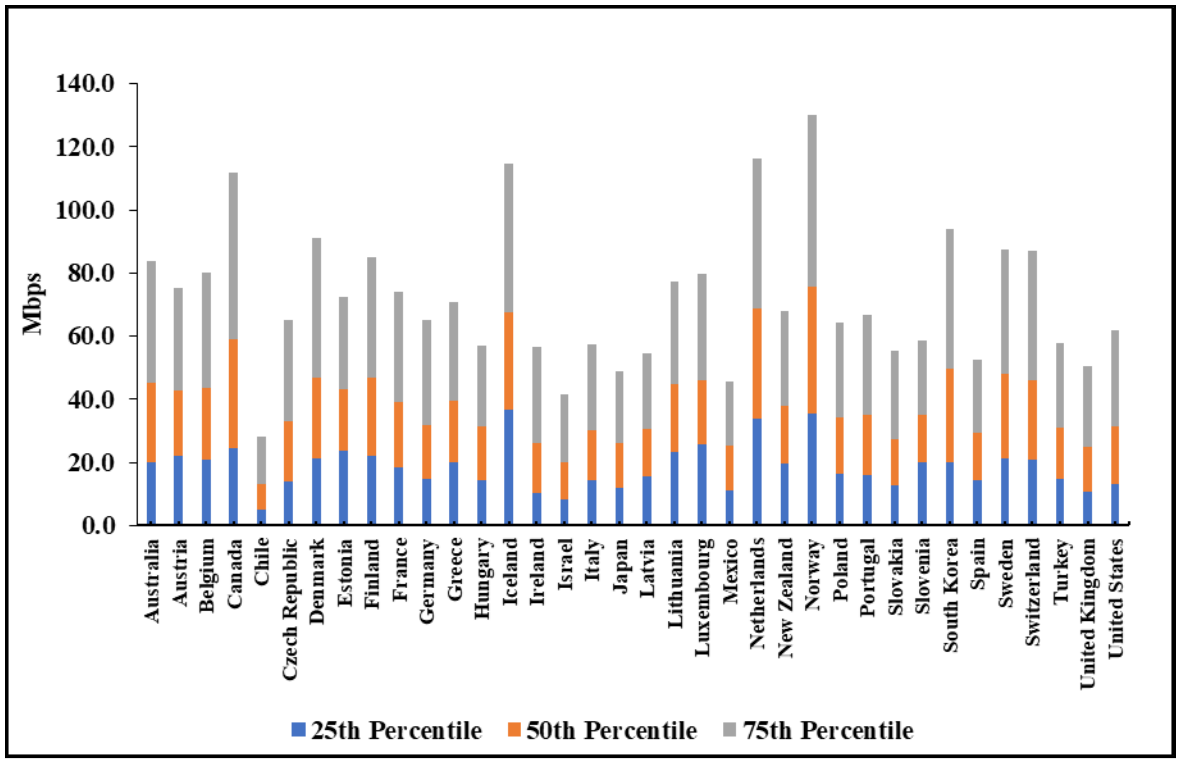


Fig. 28. Mobile Broadband – 4G LTE Mean Download Speeds for G7 Countries and South Korea (2017-2021)

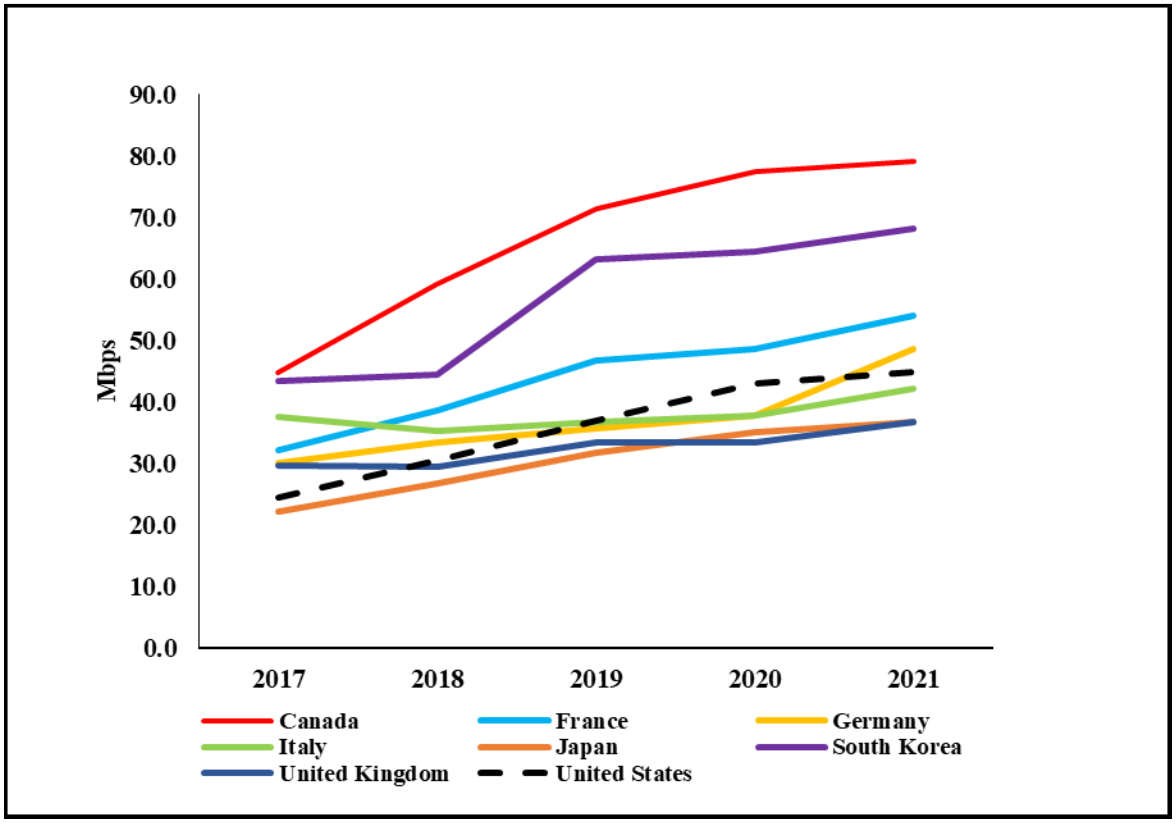


Fig. 29. Mobile Broadband – 4G LTE Mean Download Speed by Country (2021)

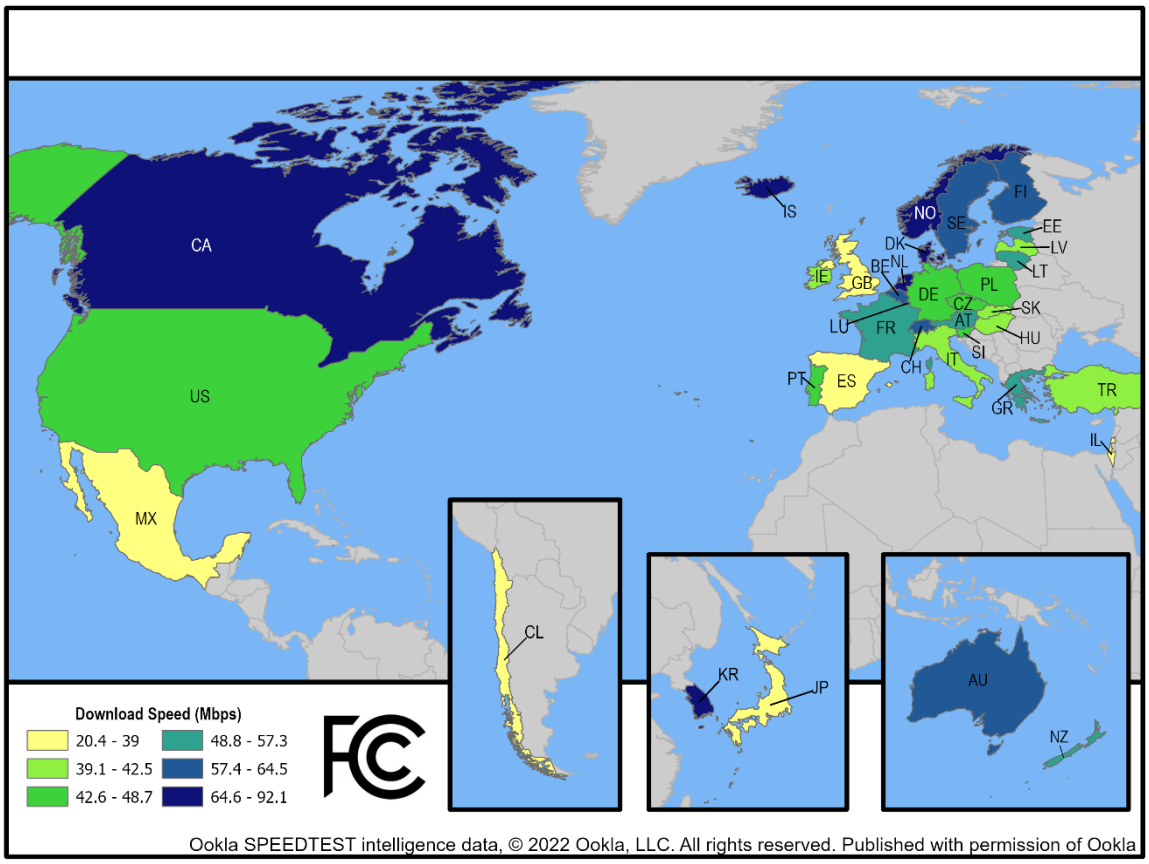


Fig. 30. Mobile Broadband – 4G LTE Mean Upload Speed by Country (2021)

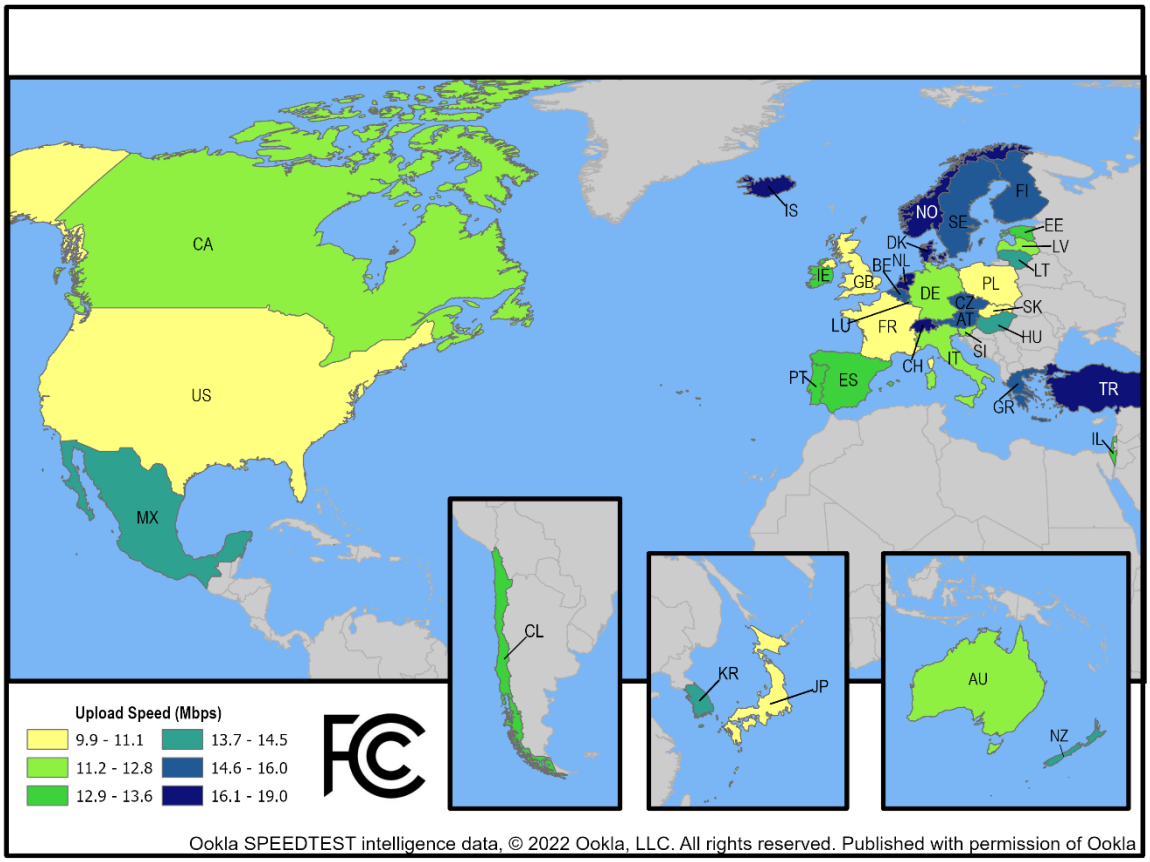


Fig. 31. Mobile Broadband – 4G LTE Mean Latency by Country (2021)

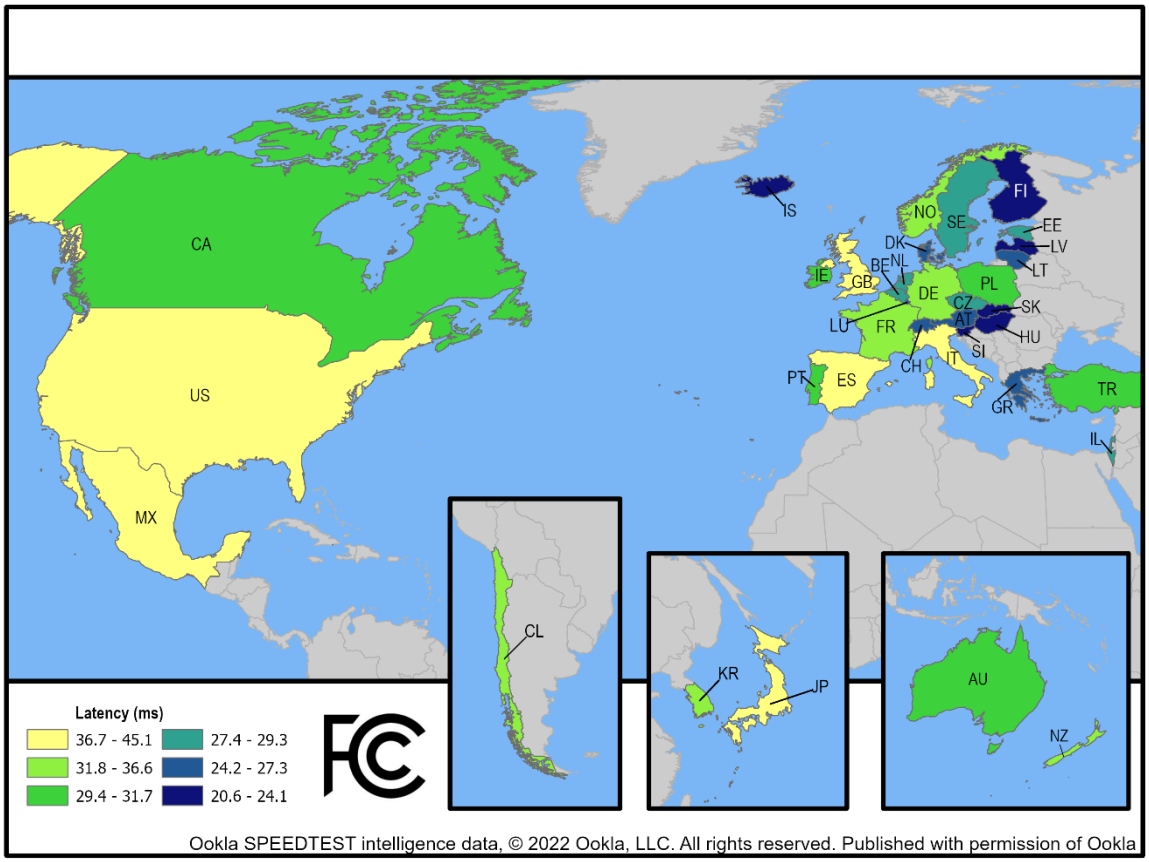


Fig. 32. Mobile Broadband – 4G LTE City Count and Test Count by Country (2017-2021)

Country	Test Count (1000s)					City Count				
	2017	2018	2019	2020	2021	2017	2018	2019	2020	2021
Australia	2,567	3,310	3,711	2,992	1,497	10,240	11,139	12,240	9,762	9,351
Austria	872	912	872	847	470	1,396	1,402	1,398	2,203	2,144
Belgium	165	182	214	196	135	602	607	610	600	604
Canada	1,180	1,130	1,255	837	537	2,359	2,395	2,628	2,741	2,613
Chile	768	1,430	1,245	1,246	961	227	241	245	1,338	1,762
Czech Republic	187	211	313	337	238	4,838	4,974	5,333	5,369	5,081
Denmark	502	558	559	563	297	586	586	615	629	625
Estonia	184	239	200	185	112	1,965	3,388	3,510	3,536	3,323
Finland	1,733	1,823	1,838	1,679	966	85	83	396	1,720	2,485
France	3,649	4,209	3,187	2,867	1,943	27,016	28,838	29,598	30,696	29,942
Germany	1,971	2,634	2,907	2,901	2,152	10,470	10,679	10,865	10,992	10,803
Greece	408	477	510	678	671	4,649	5,283	5,960	6,245	6,468
Hungary	427	577	618	630	413	2,843	2,922	2,923	2,921	2,805
Iceland	22	30	20	15	8	80	82	100	99	98
Ireland	205	291	339	371	203	140	148	143	148	144
Israel	477	606	651	640	420	925	969	1,023	1,036	1,040
Italy	5,268	11,786	9,563	9,039	5,808	28,550	33,594	34,517	35,959	34,322
Japan	2,585	2,186	1,802	2,117	1,957	1,930	1,996	1,826	1,765	1,760
Latvia	216	219	247	240	162	1,084	1,171	1,242	1,271	1,218
Lithuania	156	171	202	187	135	2,207	2,340	2,390	2,515	2,338
Luxembourg	36	35	28	25	15	349	365	361	371	232
Mexico	1,498	2,230	2,244	2,200	1,639	3,855	4,958	6,018	7,579	8,213
Netherlands	802	850	880	760	420	2,404	2,429	2,428	2,415	2,384
New Zealand	140	138	159	139	88	1,326	1,465	1,574	1,599	1,536
Norway	245	235	209	203	122	682	685	1,619	2,055	1,884
Poland	2,235	2,213	2,013	1,842	1,178	3,791	3,856	7,913	12,833	11,641
Portugal	249	316	305	276	179	1,128	1,142	1,264	1,397	1,370

Country	Test Count (1000s)					City Count				
	2017	2018	2019	2020	2021	2017	2018	2019	2020	2021
Slovakia	168	198	231	259	159	2,190	2,305	2,399	2,516	2,410
Slovenia	118	130	171	163	100	4,161	4,247	4,261	4,316	3,907
South Korea	159	272	387	172	122	162	162	162	162	162
Spain	663	698	727	766	509	7,833	8,677	9,639	10,729	9,668
Sweden	89	105	120	125	78	405	414	434	503	476
Switzerland	657	873	970	810	475	2,525	2,542	2,569	2,530	2,494
Turkey	1,097	1,513	1,702	1,736	1,164	2,208	2,784	3,428	7,042	6,754
United Kingdom	3,464	3,772	4,199	3,916	2,310	6,331	6,407	6,494	10,645	10,254
United States	**20,657**	**18,576**	**17,941**	**13,104**	**7,198**	**25,922**	**25,975**	**26,346**	**26,345**	**25,393**

C. Mobile Broadband – 5G Results

45. Figure 33 presents the number of tests in the sample for each country in 2021, as well as the number of cities with 5G tests in each country. In 2021, the United States had almost 8.5 million 5G speed tests, and the downward trend in 4G LTE tests in the United States during the last several years indicates that mobile Ookla app users were testing more frequently on 5G networks than on 4G LTE networks. The United States had 5G tests recorded in over 20,000 cities which is about 80% of the number of U.S. cities that recorded 4G LTE tests.

46. Figure 34 compares mean 5G download speeds, upload speeds, and latency by country in 2021. In 2021, the United States ranked 27th out of 36 countries with a mean download speed of 187.7 Mbps, and Lithuania ranked 1st with a mean download speed of 668.0 Mbps. For mean 5G upload speeds in 2021, the United States ranked 31st with a mean upload speed of 23.5 Mbps, and Lithuania ranked 1st with a mean upload speed of 62.9 Mbps. For mean 5G latency in 2021, the United States ranked 33rd with a mean latency of 33.0 ms, and Iceland ranked 1st with a mean latency of 14.4 ms.

47. Figure 35 compares mean 5G download speeds by country and U.S. state capital cities in 2021. In 2021, the mean download speed in Washington, D.C. was 363.7 Mbps, which ranked 13th out of 86 capital cities from both countries and states. The highest ranked U.S. state capital city in 2021 was Salt Lake City, Utah which ranked 2nd with a mean download speed of 613.7 Mbps. Three other state capital cities ranked in the top ten: Harrisburg, Pennsylvania (3rd – 528.2 Mbps); Des Moines, Iowa (6th – 507.9 Mbps); and Little Rock, Arkansas (9th – 450.9 Mbps).

48. Figure 36 presents a map of mean 5G download speeds by country in 2021.[59] Mean download speeds in North America ranged from 176.8 Mbps to 321.9 Mbps. The six countries with the highest mean download speeds, including Lithuania, Turkey, South Korea, Norway, Iceland, and Sweden, had a range of download speeds from 394.9 Mbps to 668.0 Mbps. The six countries with the lowest mean download speeds, including Poland, Czech Republic, the Netherlands, Italy, Canada, and Germany, had a range of download speeds from 103.9 Mbps to 181.9 Mbps. Several Northern European countries were among the ten countries with the highest mean download speeds, whereas several countries in central Europe, such as Germany, the Netherlands, and Poland, were among countries with the lowest mean download speeds.

49. Figure 37 presents a map of mean 5G upload speeds by country in 2021.[60] Mean upload speeds in North America ranged from 23.5 Mbps to 57.9 Mbps. The six countries with the highest mean download speeds, including Lithuania, Turkey, Mexico, Sweden, Norway, and South Korea, had a range of upload speeds from 48.1 Mbps to 62.9 Mbps. The six countries with the lowest mean download speeds, including the United Kingdom, France, Poland, Italy, Chile, and the United States, had a range from 20.3 Mbps to 23.5 Mbps.

50. Figure 38 presents a map of mean 5G latency by country in 2021.[61] Mean latency in North America ranged from 23.8 ms to 33.0 ms. The lowest latency was generally observed in the Baltic countries and in Southeastern European countries, such as Slovakia and Slovenia, along with Iceland and Chile.

[59] Each country's mean 5G download speed values are reported in Figure 34. *See infra* Fig. 34.

[60] Each country's mean 5G upload speed values are reported in Figure 34. *See infra* Fig. 34.

[61] Each country's mean 5G latency values are reported in Figure 34. *See infra* Fig. 34.

Fig. 33. Mobile Broadband – 5G City Count and Test Count by Country (2021)

Country	Test Count (1000s)	City Count
Australia	703	2,619
Austria	92	962
Belgium	12	266
Canada	268	1,001
Chile	18	187
Czech Republic	52	953
Denmark	135	596
Estonia	5.7	219
Finland	303	651
France	389	9,582
Germany	591	7,485
Greece	155	1,416
Hungary	45	328
Iceland	3.7	18
Ireland	56	109
Israel	81	513
Italy	452	10,878
Japan	279	1,232
Latvia	3.6	73
Lithuania	0.7	22
Luxembourg	8.1	48
Mexico	4.0	36
Netherlands	234	2,101
New Zealand	19.4	89
Norway	68.5	394
Poland	138	1,818
Portugal	24.0	444
Slovakia	13.8	176
Slovenia	17.8	664
South Korea	102	150
Spain	103	2,109
Sweden	24.6	108
Switzerland	273	2,358
Turkey	0.9	8
United Kingdom	1,357	3,766
United States	**8,478**	**20,541**

Fig. 34. Mobile Broadband – 5G Mean Download Speed, Upload Speed, and Latency by Country (2021)

Country	Download		Upload		Latency	
	Rank	Mbps	Rank	Mbps	Rank	ms
Australia	8	314.9	25	28.2	21	22.5
Austria	30	182.1	26	27.4	24	23.8
Belgium	26	191.0	27	25.7	20	22.4
Canada	32	176.8	28	25.1	23	23.8
Chile	21	212.8	32	22.8	6	16.9
Czech Republic	35	123.9	14	34.9	22	23.0
Denmark	25	198.3	13	36.1	15	20.0
Estonia	22	207.7	15	33.7	5	16.6
Finland	10	269.7	22	30.9	10	19.0
France	18	227.1	35	20.4	32	31.3
Germany	31	181.9	21	31.4	27	26.7
Greece	12	261.5	17	32.2	11	19.0
Hungary	13	257.1	10	38.7	8	17.8
Iceland	5	424.5	8	41.4	1	14.4
Ireland	15	253.1	18	31.8	12	19.1
Israel	28	187.7	23	30.1	9	18.7
Italy	33	173.2	33	22.6	36	35.6
Japan	19	219.9	30	23.7	35	34.4
Latvia	20	213.9	29	23.9	4	16.2
Lithuania	1	668.0	1	62.9	7	17.0
Luxembourg	14	255.7	12	36.7	25	24.6
Mexico	7	321.9	3	57.9	30	30.1
Netherlands	34	152.0	11	38.6	18	21.4
New Zealand	9	304.9	19	31.6	28	28.1
Norway	4	465.3	5	51.2	19	21.7
Poland	36	103.9	34	22.1	26	25.6
Portugal	11	268.5	9	38.8	16	20.3
Slovakia	29	184.9	16	32.7	2	14.6
Slovenia	17	234.2	20	31.6	3	15.8
South Korea	3	496.2	6	48.1	17	21.2
Spain	23	205.2	24	28.9	31	30.2
Sweden	6	394.9	4	51.8	13	19.4
Switzerland	16	242.4	7	42.8	14	19.8
Turkey	2	562.6	2	58.7	29	29.6
United Kingdom	24	202.4	36	20.3	34	33.9
United States	27	187.7	31	23.5	33	33.0

Fig. 35. Mobile Broadband – 5G Mean Download Speed by Country Capital and U.S. State Capital Cities (2021)

City, Country/State	2021	
	Rank	Mbps
Canberra, Australia	24	299.3
Vienna, Austria	49	201.3
Brussels, Belgium	54	179.6
Ottawa, Canada	56	174.8
Santiago, Chile	42	218.5
Prague, Czech Republic	64	135.9
Copenhagen, Denmark	36	253.1
Tallinn, Estonia	38	250.2
Helsinki, Finland	29	278.0
Paris, France	32	270.6
Berlin, Germany	45	207.8
Athens, Greece	34	263.9
Budapest, Hungary	37	252.7
Reykjavik, Iceland	10	420.1
Dublin, Ireland	28	281.8
Jerusalem, Israel	55	175.7
Rome, Italy	50	200.8
Tokyo, Japan	46	207.2
Riga, Latvia	40	244.5
Vilnius, Lithuania	1	681.3
Luxembourg City, Luxembourg	31	272.6
Mexico City, Mexico	12	372.8
Amsterdam, Netherlands	60	148.9
Wellington, New Zealand	21	308.0
Oslo, Norway	7	502.0
Warsaw, Poland	69	94.8
Lisbon, Portugal	23	299.8
Bratislava, Slovakia	51	199.0
Ljubljana, Slovenia	27	282.9
Seoul, South Korea	4	522.1
Madrid, Spain	35	254.8
Stockholm, Sweden	8	493.0
Bern, Switzerland	39	246.2
Ankara, Turkey	5	514.4
London, United Kingdom	48	202.0
Albany, NY	59	150.7
Annapolis, MD	58	156.9
Atlanta, GA	20	315.2
Augusta, ME	83	66.0
Austin, TX	57	160.7
Baton Rouge, LA	72	89.0
Bismarck, ND	71	91.7
Boise, ID	33	270.0
Boston, MA	19	319.9
Carson City, NV	86	55.3
Charleston, WV	82	73.1

City, Country/State	2021	
Cheyenne, WY	80	75.2
Columbia, SC	15	354.8
Columbus, OH	25	293.0
Concord, NH	78	78.7
Denver, CO	17	332.6
Des Moines, IA	6	507.9
Dover, DE	66	126.2
Frankfort, KY	65	127.6
Harrisburg, PA	3	528.2
Hartford, CT	30	276.6
Helena, MT	67	98.1
Honolulu, HI	63	137.7
Indianapolis, IN	14	362.9
Jackson, MS	79	76.8
Jefferson City, MO	73	88.9
Juneau, AK	85	56.4
Lansing, MI	61	142.0
Lincoln, NE	74	85.5
Little Rock, AR	9	450.9
Madison, WI	76	83.7
Montgomery, AL	77	79.7
Montpelier, VT	70	93.7
Nashville, TN	22	305.1
Oklahoma City, OK	44	213.3
Olympia, WA	81	74.3
Phoenix, AZ	47	204.4
Pierre, SD	62	138.3
Providence, RI	18	322.2
Raleigh, NC	16	334.6
Richmond, VA	11	413.7
Sacramento, CA	26	291.3
Saint Paul, MN	41	239.5
Salem, OR	53	182.1
Salt Lake City, UT	2	613.7
Santa Fe, NM	75	85.2
Springfield, IL	68	96.0
Tallahassee, FL	52	183.1
Topeka, KS	84	65.1
Trenton, NJ	43	214.0
Washington, DC	13	363.7

Fig. 36. Mobile Broadband – 5G Mean Download Speed by Country (2021)

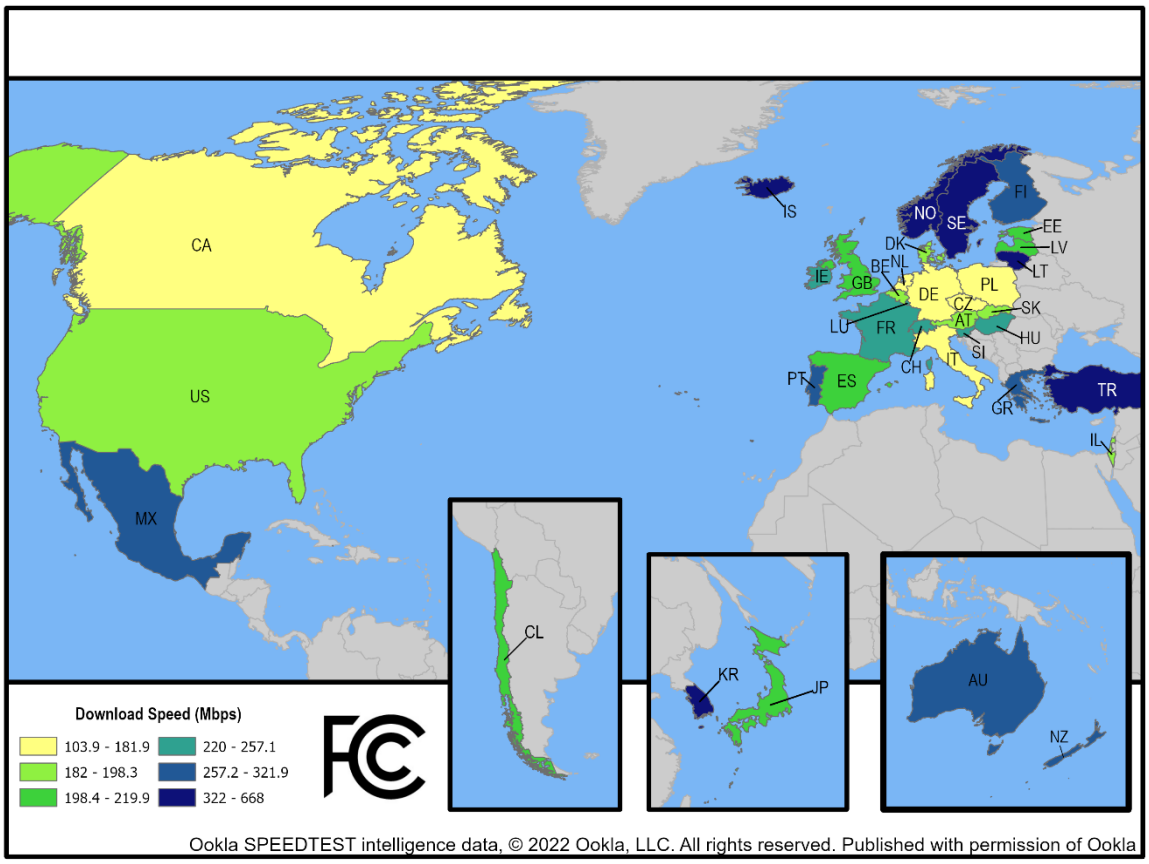


Fig. 37. Mobile Broadband – 5G Mean Upload Speed by Country (2021)

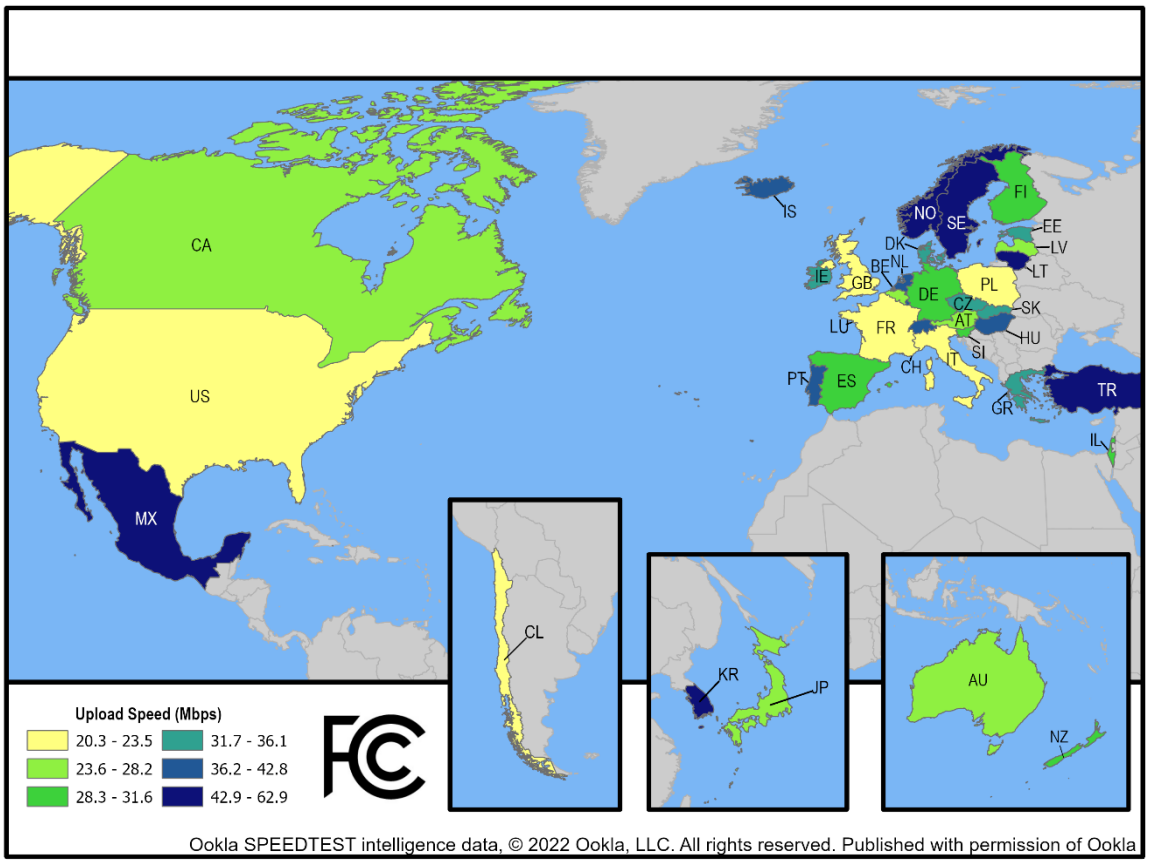
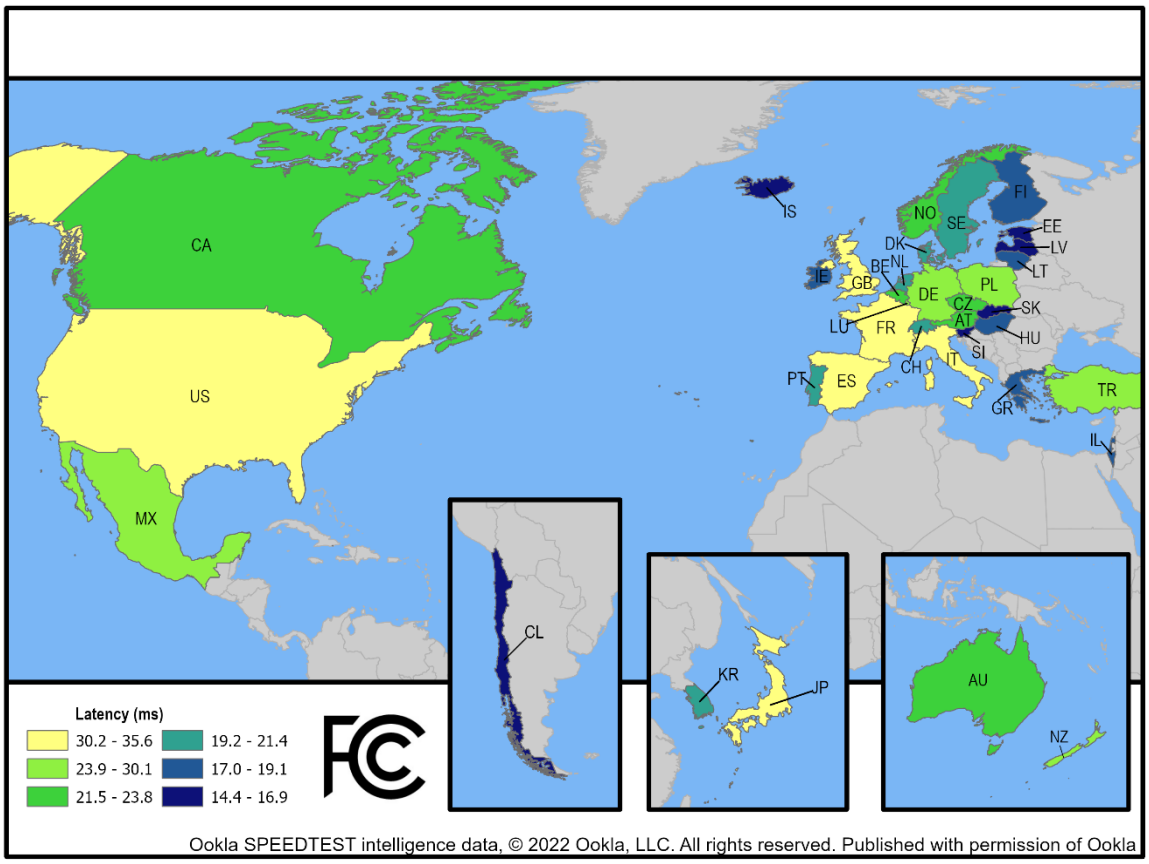


Fig. 38. Mobile Broadband – 5G Mean Latency by Country (2021)



D. Data and Analysis

51. *Data*. The FCC obtains aggregated fixed broadband and mobile broadband speed and latency datasets from Ookla for the United States and the 35 comparison countries. The annual fixed broadband datasets are aggregated to the city-platform level, whereas the annual mobile broadband datasets are aggregated to the city-platform-technology level.[62] Prior to aggregating the data, Ookla applies a set of cleaning and filtering rules to ensure the quality of the data and to remove invalid test results.[63] The Ookla Speed Test data are user-generated, meaning the users manually choose to run each speed test. Therefore, the results from these tests may represent nontypical situations (e.g., when the user is experiencing congestion issues). Because the tests are not taken randomly, they may not represent consumers' typical broadband experience.

52. *Analysis*. In our analysis, we consistently aggregate the data to higher levels using sample counts as a weight.[64] First, we aggregate over platforms for fixed broadband, mobile – 4G LTE broadband, and mobile – 5G broadband at the city-level. Then, we aggregate data over cities to the state-level or country-level. Ideally, we would prefer having an observation for each broadband subscriber or at least a representative sample of all broadband users. But as subscribers choose to opt-in to Ookla's service, this is unlikely to be the case. For example, if the ratio of Ookla users relative to broadband subscribers is greater in urban areas compared to rural areas, it may produce an urban bias in the dataset at the country-level.

53. Our city-level and country-level results are not directly comparable to city-level and country-level results published by Ookla because Ookla applies its aggregation methodology to the given level of aggregation before calculating statistics, whereas we weigh the lower level of disaggregation by sample count to aggregate the data to higher levels.

IV. BROADBAND PRICING COMPARISONS

54. Congress directed the Commission to compare broadband pricing in "communities of a population size, population density, topography, and demographic profile that are comparable to the population size, population density, topography, and demographic profile of various communities within the United States."[65] To meet this directive, we first collected a comprehensive sample of advertised prices and terms for over 1,000 fixed and mobile broadband plans from the largest broadband providers in the United States and 25 other countries.[66] We then ranked the countries by fixed and mobile broadband

[62] By platform, we refer to the testing platform such as the Android App, the iOS App, a web browser, or other Ookla testing platforms.

[63] For the 2018 and 2019 mobile - 4G LTE data, Ookla adopted additional minor changes to its cleaning and filtering methodology. For more information regarding Ookla's methodology, *see* Brian Connolly, *How Ookla Ensures Accurate, Reliable Data: A Guide to Our Metrics and Methodology (Updated for 2020)* (Apr. 28, 2020), https://www.speedtest.net/insights/blog/how-ookla-ensures-accurate-reliable-data-2020/.

[64] As in the *Sixth International Broadband Data Report* and the *2020 International Broadband Data Report*, this *2022 IBDR* used sample counts as weights when aggregating. Earlier *IBDRs* relied on test counts for the weights because sample counts were not available. *See generally Sixth International Broadband Data Report*; *2020 Communications Marketplace Report*, 36 FCC Rcd at 3749, Appx. G: International Broadband Data Report.

[65] 47 U.S.C. § 1303(b)(2); *see also* RAY BAUM'S Act of 2018.

[66] We analyzed the same 26 countries as in the *2020 International Broadband Data Report*. The *Sixth International Broadband Data Report* included three additional comparison countries: Chile, Japan, and South Korea. These countries were excluded from the *2018 CMR International Broadband Data Report* and *2020 International Broadband Data Report* due to resource limitations and the difficulty of collecting information from the websites of providers in Japan and South Korea. *See Sixth International Broadband Data Report*, 33 FCC Rcd at 981, para. 6; *Communications Marketplace Report et al.*, GN Docket No. 18-231 et al., Report, 33 FCC Rcd 12558, Appx. E:

(continued….)

prices from the least expensive (1st) to the most expensive (26th) according to two different methodologies. The first method calculates weighted average prices for a set of fixed broadband products based on download speeds and for a set of mobile broadband products based on data usage allowances.[67] These two weighted average prices are then used to calculate an overall average price, and countries are ranked by this measure.[68]

55. To better account for differences in the characteristics of the comparison communities and their broadband offerings, the second method constructs hedonic fixed and mobile broadband price indexes from a regression of broadband prices on broadband product characteristics and country-level variables to control for differences in broadband market conditions.[69] The hedonic method seeks to better assess how U.S. broadband prices compare to prices in other countries after accounting for the types of country-level cost and demographic differences identified by Congress that likely affect broadband pricing, including population density, topography, income, and education levels. The hedonic price index also adjusts for observable differences in broadband plan characteristics across countries (e.g., speed and usage limits) and generates prices for a set of standardized broadband plans to facilitate pricing comparisons across countries. The results of our fixed and mobile broadband pricing analyses demonstrate that accounting for these country-level differences in cost, demand, and quality factors provides a substantially different assessment of the competitiveness of the U.S. broadband market.[70]

A. Overview and Data Highlights

56. Comparing broadband prices across countries presents several challenges. One difficulty is that broadband product offerings are complex and vary widely across countries. Among other aspects, the plans may differ with respect to: (1) download and upload speeds; (2) types of technology used to deliver broadband services; (3) limitations on use, including limits on upload and download volumes; (4) contractual conditions; (5) additional services included; and (6) consequences of exceeding usage limits, with some plans reducing speeds, imposing surcharges, or shutting off service. In addition, broadband service is also frequently purchased as part of a discounted bundle of services, making it difficult to identify the price of the broadband service. Finally, differences across countries in the quality of

(Continued from previous page)
International Broadband Data Report (2018); *2020 Communications Marketplace Report*, 36 FCC Rcd at 3750, Appx. G-1: International Broadband Data Report, para. 2.

[67] The data were collected between February and July of 2022. The data we use for these comparisons contain the terms and advertised prices for select fixed and mobile broadband plan offerings available on the websites of the largest broadband providers in each country.

[68] Our broadband price index measures the dollar amount that U.S. broadband subscribers would need to have added or subtracted from their incomes to purchase the same basket of broadband services under the pricing structures in other countries. Quantity weights for the price index are the share of broadband subscribers in the United States that, for fixed broadband, are from each of the three broadband speed tiers and, for mobile broadband, are from each of the three data usage tiers in the analyses.

[69] A hedonic regression provides an empirical summary of how prices vary with the characteristics of a good (e.g., download speed). In this *Report*, the hedonic regression builds on the price index method by allowing for the adjustment of prices for quality, cost, and demographic differences across countries and then predicting broadband prices for each country at the average U.S. values of these variables.

[70] A 2021 study by Israel, Katz, and Keating reached similar conclusions regarding the importance of accounting for quality differences, bundling, as well as supply and demand factors in order to provide meaningful comparisons of broadband prices across countries. The same logic they apply led us to implement our current price comparison approach in the *Sixth International Broadband Data Report*. Mark Israel, Michael Katz, & Bryan Keating, International Broadband Price Comparisons Tell Us Little About Competition and Do Not Justify Broadband Regulation (2021), https://www.ncta.com/sites/default/files/2021-05/international-price-comparisons-paper-11-may-2021.pdf.

networks deployed, cost factors (e.g., population density and topography), and demand factors (e.g., demographics and content quality), would be expected to affect pricing, all else equal. Our hedonic price index analysis accounts for these differences, with the intention of producing comparisons that are meaningful for the purposes of assessing which countries have broadband policies that foster competition and provide the greatest consumer benefits.[71]

1. Fixed Broadband Pricing Results

57. *Broadband Price Index Results*. This analysis compares broadband prices across countries by calculating weighted average prices within each fixed broadband download speed tier and then aggregating these prices into an overall average fixed broadband price measure.

- For broadband service purchased on a standalone basis, we find that the United States ranks 24th out of the 26 countries in our broadband price index, not adjusting for cost, quality, and demand factor differences across countries.[72]
- For broadband service purchased in a bundle with video service, we find that the United States ranks 24th out of the 26 countries, not adjusting for cost, quality, and demand factor differences across countries.
- Overall, we find that the United States ranks 24th out of the 26 countries, not accounting for cost, quality, and demand differences across countries.

58. *Hedonic Price Index Results*. The hedonic price index adjusts broadband prices for differences in broadband demand factors (e.g., demographics) and network cost profiles across countries using a hedonic regression framework. The hedonic regression also adjusts for observable differences in broadband plan characteristics across countries (e.g., the speed and usage limits of each plan) and generates prices for a set of standardized broadband plans in every country to facilitate pricing comparisons. Based on the predicted prices for these standardized plans, we then calculate a hedonic price index to serve as our pricing comparison measure across countries. This index estimates what the average U.S. consumer would expect to pay for service in each country if those countries had similar demand characteristics, network cost structures, and broadband offerings as the United States.[73]

- After adjusting for differences in cost and demographic factors across countries, as well as differences in broadband plan characteristics, our hedonic price index estimates that the United States ranks 13th out of the 26 countries.[74]
- The U.S. ranking remains unchanged at 13th after adjusting for our measure of fixed broadband network quality.

[71] Using standard discrete choice consumer demand models, it is simple to construct examples where consumers in a country with higher broadband prices receive greater consumer surplus (i.e., are better off) from their broadband services, compared to consumers in a country with lower prices. Similarly, higher prices may not indicate that one market is less competitive than another in terms of the economic profits earned by broadband firms. As such, simple broadband price comparisons may not be appropriate for comparing the effectiveness of competition and regulatory policies across countries.

[72] *See infra* Fig. 41.

[73] The country rankings would not change if, instead of using the United States as our baseline country, we predicted prices at the values of the country-level variables for any other country or at the average of these variables across all countries. The only difference in our results would be in the levels of the predicted prices. Due to the provider-level random coefficients in the hedonic model, changing the values of the plan characteristics used to predict prices would change the country rankings.

[74] *See infra* Fig. 43.

- After further price adjustment for measures of broadband content quality, the United States ranks 5th among the 26 countries.

2. Mobile Broadband Pricing Results

59. Our mobile broadband pricing comparison methodology is the same as our fixed broadband pricing comparison methodology with two exceptions. First, because most mobile broadband plans are sold by data usage allowance rather than speed, we classify mobile broadband products by data usage allowances rather than by download speeds.[75] Second, we account for bundling in this sector by analyzing multi-line data plans (i.e., family plans) rather than the video and broadband bundling that is more common in the fixed broadband market.

60. *Broadband Price Index.* This analysis compares countries by calculating weighted average prices for mobile plans that fall within specified data usage tiers and then aggregates these prices into an overall average mobile broadband price.

- The United States ranks 24th in single-line plan pricing and 24th in multi-line pricing out of the 26 countries, not adjusting for cost, quality, and demand factor differences across countries.[76]
- Overall, we find that the United States ranks 24th out of the 26 countries in our mobile broadband price index, not adjusting for cost and demand factor differences across countries.

61. *Hedonic Price Index Results.* As in our fixed broadband analysis, we calculate a hedonic index that estimates what the average U.S. consumer would expect to pay for her level of mobile broadband service in each country if that country had similar demand characteristics, network cost structure, and broadband plan characteristics as the United States.

- After adjusting for differences across countries in the cost and demographic factors, as well as differences in mobile broadband plan characteristics, our hedonic price index estimates that the United States ranks 13th out of the 26 countries.[77]
- Adjusting for mobile network quality measures, the United States ranks 12th out of 26 countries.
- After we further adjust the mobile hedonic price index for our measures of content quality, the United States ranks 8th out of 26 countries.

62. *Combining Fixed and Mobile Hedonic Price Index Rankings.* Typical consumers in the United States subscribe to both fixed and mobile broadband services, so we also measure overall broadband price by calculating the average monthly cost that U.S. consumers would pay to subscribe to both services in each country.[78] After accounting for differences in costs, demographics, and broadband plan characteristics, we find that the United States ranks 15th overall by this measure, at $121.16 per month for a mobile and fixed broadband connection.[79] Adjusting for network quality measures, the Unites States ranking improves to 12th.[80] After accounting for additional differences in content quality,

[75] In some countries, providers have begun to differentiate plans based on maximum download speeds, especially for various tiers of unlimited data plans, in addition to differentiating plans based on data usage allowances.

[76] *See infra* Fig. 44.

[77] *See infra* Fig. 46.

[78] We do not account for discounts for bundling of fixed broadband and mobile broadband services that are offered by some providers.

[79] *See infra* Fig. 48.

[80] *Id.*

the United States ranks 3rd overall by this measure, at $121.59 per month for a mobile and fixed broadband connection.[81]

B. Data

63. For our fixed broadband data analysis, we collected fixed residential broadband plan prices and terms from 84 providers in 26 countries, including the United States, between April and July 2022. To determine which providers to sample in each comparison country, we used the TeleGeography GlobalComms Database to select providers with broadband market shares of at least 10% nationally as of December 2021.[82] This threshold was chosen to balance data collection costs against the desire to obtain a representative sample of broadband pricing for each country.[83] For each provider, we collected plans from 10 randomly selected addresses in the country's capital city.[84] These addresses were then entered into providers' websites to determine the product offerings at each address. While many providers' websites displayed general "promotional splash page" plan offerings, entering an address allowed us to capture the variation in product availability within a city, as well as more detailed pricing information.[85] Where we could not collect address-level plan data, we collected "promotional splash page" plans (i.e., we assume the plan is available for at least one address in the city).[86]

64. We also collected mobile broadband plan prices and terms from 84 providers from 26 countries, including the United States, between February and April of 2022 for providers in each country with a national broadband market shares of at least 10% as of September 2021.[87] Given the wide scope of offerings by mobile providers, we limited the collection to 4G and 5G postpaid smartphone plans that allowed unlimited voice calling and texting for up to four lines (when adding lines provided a discount).[88] However, where providers did not offer plans with unlimited minutes or unlimited text messages, we collected plans with the highest number of minutes and text messages for a particular data allowance and the maximum download speed combination.

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[81] *Id.*

[82] TeleGeography, *TeleGeography GlobalComms Database*, http://www.telegeography.com (last accessed Oct. 6, 2022) (navigate to *Company Statistics*, then choose *Fixed Broadband* within the *GlobalComms Database*). *TeleGeography GlobalComms Database* is subscription-only. We obtained these data as of February 2022. There is one exception to the 10% rule: Verizon is estimated to have a national broadband market share below 10% in the United States, but it was sampled as it is the largest FTTP provider as well as the second largest Incumbent Local Exchange Carrier.

[83] On average, our sample covers about 82% of all broadband subscribers over all 26 comparison countries. The lowest total market share is about 48% while most countries have over 80% total market share covered in our sample.

[84] In some cases, a provider did not offer service in the capital city which required collecting some providers' plans from another city.

[85] If we were able to collect address-level plans, we only collected plans that were available for at least one address. Therefore, plans that were advertised on "promotional splash pages" may not have been collected if these plans were not available at any of the 10 sampled addresses.

[86] Some providers do not provide an option to enter an address to check available plans but instead require customers to call or e-mail to receive more information about availability of plans.

[87] We obtained these data as of February 2022. *See* TeleGeography, *TeleGeography GlobalComms Database*, http://www.telegeography.com (last accessed Oct. 6, 2022) (navigate to *Company Statistics*, then choose *Mobile* within the *GlobalComms Database*).

[88] By postpaid plans, we refer to plans that are paid after usage (i.e., not prepaid or "pay-as-you-go" plans). By smartphone plans, we refer to plans that have a data component.

C. Methodology

1. Fixed and Mobile Broadband Price Index Calculations

65. To compare broadband pricing across countries, we need an estimate of "the price" of broadband in each country. Our approach is to follow well-established practices in the price index literature. Price indexes calculate measures of price changes for goods and services by comparing the prices in a base period to those in a comparison period. One such index is the U.S. Consumer Price Index (CPI), calculated by the Bureau of Labor Statistics of the U.S. Department of Labor.[89] While the CPI involves measuring price changes across time periods, our application to price changes across countries is analogous with the two periods now corresponding to two different countries.

66. Both our broadband price index and hedonic price index are Laspeyres broadband price indexes.[90] In the Laspeyres index calculation shown below, $p_{j,t}$ represents the price of product j in comparison country, t, $p_{j,0}$ is the price of product j in the base country, and $q_{j,0}$ is the market share of product j in the base country. The index is therefore the ratio of the weighted average price of all of the j broadband products sold in the comparison country to the weighted average price of these same products in the base country, where the weights are the percentage of broadband consumers who choose each product in the base country.[91]

$$L(p) = \frac{\sum_{j=1}^{N} p_{j,t} q_{j,0}}{\sum_{j=1}^{N} p_{j,0} q_{j,0}}$$

67. Ideally, the price index would be calculated over every broadband plan offered in every country. However, there are at least two difficulties in doing so. First, we would need to know the number of households that subscribe to each base country plan, but we do not have these data. Second, the broadband products available in each country are not the same. Even if we had such quantity weights for the base country, they would not be applicable in the comparison countries. To deal with these issues, we classify all available broadband plans into $j = 6$ products for our mobile and fixed price indexes. For fixed broadband, we classify products by download speed tier ranges for which we have information on the share of U.S. fixed broadband households that subscribe to the speed tier.[92] We define three

[89] U.S. Bureau of Labor Statistics, *Consumer Price Index Frequently Asked Questions*, https://www.bls.gov/cpi/questions-and-answers.htm (last modified Mar. 23, 2022) (last visited Oct. 6, 2022).

[90] The Laspeyres price index yields an upper bound for the average compensating variation from a price change. Compensating variation measures the dollar amount by which a given consumer would need to have their income adjusted to obtain the same level of utility, or well-being, under the comparison prices and product choice set. *See* Ariel Pakes, *A Reconsideration of Hedonic Price Indexes with an Application to PC's*, 93 American Economic Review 1578 (2003).

[91] The United States is used as the base country for several reasons. First, the focus of this *Report* is to evaluate how the prices of broadband products purchased in the United States compare to those of other countries. Second, we have better estimates of the subscriber quantity weights for the United States than for any other country. Finally, this index ensures that U.S. broadband consumers would be at least as well-off as in higher ranked countries by measuring the dollar amount that U.S. broadband subscribers would need to have added or subtracted from their incomes to purchase the same basket of broadband services under the pricing structures in the other countries.

[92] Aggregating products in this manner is common in the differentiated products demand model literature. *See* Steven Berry, James Levinsohn, & Ariel Pakes, *Automobile Prices in Market Equilibrium*, 63 Econometrica: Journal of the Econometric Society 841 (1995); Aviv Nevo, *Measuring Market Power in the Ready-to-Eat Cereal Industry*, 69 Econometrica: Journal of the Econometric Society 307 (2001); Austan Goolsbee & Amil Petrin, *The Consumer*

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standalone fixed broadband products classified by the following download speed tiers: less than 100 Mbps; at least 100 Mbps but less than 250 Mbps; and at least 250 Mbps. We also define three additional products when these speed tiers are purchased in a bundle with video service.[93]

68. For mobile broadband, we classify products by data allowance rather than download speed[94] and define the three bundled products as multi-line data plans (i.e., "family plans"), rather than by bundles of telecommunications services as we do for fixed broadband.[95] Cisco estimates that 79% of U.S. subscribers obtain their mobile service through multi-line data plans.[96] These bundled plans are offered at greatly discounted rates and need to be properly accounted for to reflect the prices that consumers actually pay for their mobile services. We therefore define three standalone mobile broadband products (i.e., single line plans), which are classified by the following monthly data usage limits: less than or equal to 10 GB per line; greater than 10 GB but less than or equal to 25 GB per line; greater than 25 GB per line.[97] We also have three additional multi-line products when these products are bundled with additional lines.

a. Fixed and Mobile Product Shares

69. *Fixed Product Shares.* To calculate the U.S. quantity weights for each of the six products in our fixed broadband price indexes, we use the FCC Form 477 data[98] to estimate the share of U.S. households that subscribe to each of the three broadband speed tiers and an estimate from S&P Global that about 61% of all U.S. broadband households purchase their service in a bundle.[99] The resulting broadband products and their estimated U.S. market shares are shown in Figure 39 below.

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Gains from Direct Broadcast Satellites and the Competition with Cable TV, 72 Econometrica: Journal of the Econometric Society 351 (2004).

[93] By video service, we limit the scope to traditional linear TV plans and do not consider over-the-top (OTT) streaming services from the provider or from a third-party (e.g., Netflix bundled with broadband service).

[94] Relative to the mobile broadband pricing data collections in the *Sixth International Broadband Data Report* and the *2020 International Broadband Data Report*, we encountered more providers differentiating plans by download speed and/or technology (e.g., 4G vs. 5G), particularly for unlimited data plans.

[95] In some countries, providers offer mobile broadband bundled with fixed broadband. We do not consider this type of bundling in our analysis.

[96] Cisco, *Annual Internet Report (2018-2023) White Paper*, (Mar. 9, 2020), https://www.cisco.com/c/en/us/solutions/collateral/executive-perspectives/annual-internet-report/white-paper-c11-741490.html. We are treating the share of "shared data" plans as equivalent to the share of "multi-line" plans in the United States. While we were not able to incorporate a more recent estimate of single-line vs. multi-line plans in this *Report*, we do not have reason to believe that the shares have substantially changed in two years.

[97] Given the trend in higher mobile data usage and providers offering more higher data cap and unlimited data plans, we have redefined our data usage tiers with respect to mobile products as compared with the *2020 International Broadband Data Report*.

[98] FCC, *Form 477 Resources*, https://www.fcc.gov/economics-analytics/industry-analysis-division/form-477-resources (last visited Oct. 6, 2022). All FCC Form 477 data used in this *Report* have been certified as accurate by the filers. We used preliminary December 2021 FCC Form 477 subscription data for these calculations. We note that the year-end FCC Form 477 data are subject to corrections, as appropriate, by the service provider, and the final data will be published in due course by the Commission. We further note that the *2022 IBDR*'s analysis may understate or overstate consumers' options for services to the extent that broadband providers fail to report data or misreport data. *See* FCC, *Explanation of Broadband Deployment Data*, https://www.fcc.gov/general/explanation-broadband-deployment-data (last visited Oct. 6, 2022) (describing quality and consistency checks performed on providers' submitted data and explaining any adjustments made to the FCC Form 477 data as filed).

[99] S&P Global, *Estimated broadband-only homes as a percentage of wireline broadband homes, Q1'19-Q4'21* (last accessed July 18, 2022) (S&P Global). We do not provide URLs for S&P Global articles and data throughout this section because it is a paid subscription service that cannot be publicly accessed.

Fig. 39. Fixed Broadband Product Shares

Product	Download Speed Tier	Bundle Share	Speed Tier Share	Product Share	Plans
1	**Standalone: 0 < Mbps < 100**	38.67%	28.30%	10.95%	122
2	**Standalone: 100 ≤ Mbps < 250**	38.67%	33.47%	12.94%	104
3	**Standalone: 250 ≤ Mbps**	38.67%	38.22%	14.78%	232
4	**Bundle: 0 < Mbps < 100**	61.33%	28.30%	17.36%	133
5	**Bundle: 100 ≤ Mbps < 250**	61.33%	33.47%	20.53%	117
6	**Bundle: 250 ≤ Mbps**	61.33%	38.22%	23.44%	252

Source: S&P Global; December 2021 FCC Form 477 data.

70. *Mobile Product Shares.* To construct our mobile broadband price indexes, we need to estimate the percentage of U.S. consumers who subscribe to each of the six mobile products defined by data usage allowance and number of lines. We follow the same approach as the *2020 International Broadband Data Report* of estimating product shares based on the estimated distribution of mobile data usage in the United States, but we adjust for the continued growth in mobile broadband data usage.[100] In Figure 40 below, we calculate the product shares for each of the six standardized mobile broadband products.[101] The column "Data Usage (Per Line) Share" provides the estimated percentage of all subscribers that consume an amount of data within the corresponding ranges of data usage and number of lines on the plan. For example, 46% of all single-line plans in the United States are estimated to consume between 0 and 10 GB of data per line (product 1), while 58% of multi-line plans would be expected to consume this amount of data per line (product 4).[102] We then multiply these estimated single-line and multi-line data usage shares by the percentage of all U.S. plans that are single versus multi-line to arrive at the final mobile product shares.[103]

[100] *See 2020 Communications Marketplace Report*, 36 FCC Rcd at 3797, Appx. G-3: International Broadband Data Report, para. 23.

[101] *See infra* Fig. 47 (estimated log-normal parameters and distribution).

[102] We use the terms "shared plan," "multi-line plan," and "family plan" interchangeably in this *Report*. However, some multi-line plans may have shared data among the lines, whereas some other multi-line plans have separate data allowances for each line. We do not distinguish between shared data and separate data allowances for multi-line plans.

[103] In a change from the *2020 International Broadband Data Report*, we include all multi-line plans in the three categories of multi-line products (i.e., we do not limit the multi-line product definition to a specified number of lines).

Fig. 40. Mobile Broadband Product Shares

Product	Lines	Data Allowance Tier (Per Line)	Bundling Share	Data Usage Share (Per Line)	Product Share	Plans
1	**1**	**0 < GB ≤ 10**	21%	46%	9.7%	99
2	**1**	**10 < GB ≤ 25**	21%	30%	6.3%	79
3	**1**	**GB > 25**	21%	24%	5.0%	218
4	**2-4**	**0 < GB ≤ 10**	79%	58%	45.8%	373
5	**2-4**	**10 < GB ≤ 25**	79%	26%	20.5%	313
6	**2-4**	**GB > 25**	79%	16%	12.6%	719

Source: Cisco, *Annual Internet Report (2018-2023) White Paper* (Mar. 9, 2020), https://www.cisco.com/c/en/us/solutions/collateral/executive-perspectives/annual-internet-report/white-paper-c11-741490.html; Ericsson, *Ericsson Mobility Visualizer*, https://www.ericsson.com/en/reports-and-papers/mobility-report/mobility-visualizer?f=1&ft=2&r=2,3,4,5,6,7,8,9&t=1,2,3,4,5,6,7&s=4&u=1&y=2021,2027&c=3 (last visited Oct. 6, 2022) (*Ericsson Mobility Visualizer*).

b. Product Price Calculations

71. Calculating comparable prices for each of the six broadband products for each country is more difficult. To calculate such prices using the Laspeyres index formula mentioned above, we follow two common approaches in the price index literature. The first approach estimates a price for each of the six products in a country by calculating the weighted average price of all plans that fall within that product category. The second approach estimates a hedonic regression model and then uses this model to predict the prices for each of the six fixed and mobile broadband products.

72. *Broadband Price Index Prices.* In our broadband price index calculations, we first calculate simple unweighted average prices for each provider's offerings that fall into each of the six product categories. We then use the market share of each provider to calculate a country-level weighted average for each of the six broadband products from these provider-level prices.[104] Finally, we calculate an average broadband price for each country by weighting these six product-level prices by the estimated percentage of consumers in the United States that subscribe to each product category. The prices we calculate using this methodology for our fixed broadband price index are shown in Figure 41, and the mobile price index prices are shown in Figure 44 below.

73. *Hedonic Price Index Prices.* Many studies compare advertised prices for "similar" telecommunications services, as we have done in our broadband price index calculations.[105] While such price comparisons are appropriate for descriptive assessments of price levels, they are less useful for identifying which countries have industry structures and policies that produce the greatest broadband consumer benefits.[106] The challenge in comparing prices across markets is that the supply and demand

[104] If a provider does not offer any plans in the product category, that provider's market share is distributed proportionally to the providers that do offer plans in the product category (i.e., the logit assumption). If no providers in the country offer the highest standalone (bundled) product, we assign the next highest available standalone (bundled) product price to the highest missing product price(s). *See infra* para. 74.

[105] For example, *see* Carol Corrado & Olga Ukhaneva, *Hedonic Prices for Fixed Broadband Services: Estimation across OECD Countries*, (Oct. 20, 2016), https://www.oecd-ilibrary.org/docserver/5jlpl4sgc9hj-en.pdf?expires=1603997556&id=id&accname=guest&checksum=1D0A776B692D8F368F8A696A24A0E702.

[106] In the language of economics, price indexes are positive analyses that describe what the price differences are across countries or what the typical consumer would be expected to pay for broadband in each country. However, cross-country price differences are frequently used to normatively rank countries and are interpreted as meaningful differences in industry performance or regulatory policies. In order to provide a more normative assessment, our analysis also accounts for potentially exogenous supply and demand differences across countries that would result in price differences regardless of broadband policy differences. However, given the limited number of country-level

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factors which generate different broadband prices and offerings vary widely from one market to the next. An analysis that seeks to make normative comparisons (i.e., how well a country is doing relative to others) of broadband prices across countries would, at a minimum, need to account for: (1) the different costs of deploying and operating broadband networks; (2) demographic differences that affect demand for broadband service; (3) multi-product bundling in broadband pricing; (4) different product offerings in each country; and (5) the availability and quality of complementary content and applications. Rankings that account for these factors are necessary to inform government competition and regulatory policy because the exogenous determinants of price that are outside the scope of competition policy (e.g., terrain and population density) may differ across countries and distort comparisons.[107]

74. A hedonic regression provides an empirical summary of how prices vary with the characteristics of a good and is a standard technique used to adjust prices for differences in quality in price indexes such as the CPI.[108] Our approach extends the standard hedonic framework by also controlling for country-level cost and demand factor differences, instead of only controlling for product characteristics (e.g., download speed).[109] We estimate four hedonic regression models and then use the predicted prices from these models to construct hedonic price indexes. While the details of the hedonic modeling are contained in section IV.F.2, we summarize the basic approach here. For both fixed and mobile broadband price estimates, the first model regresses the logarithm of broadband plan price on the plan characteristics to account for how plan characteristics explain differences in plan prices across countries. The second model builds upon the first by adding country-level variables that likely affect broadband deployment costs (e.g., population density) and broadband demand (e.g., income per capita). The third model adds controls for network quality and investment. The final model adds a proxy measure for availability and quality of content that is complementary to broadband and would be expected to raise broadband demand (e.g., websites and video content availability).

75. To calculate the hedonic price index, we predict provider-specific prices from the estimated hedonic regression for six standardized broadband plans. For these price predictions, we set the product characteristics and country-level variables at typical U.S. values and use the estimated provider-specific coefficients on product characteristics to predict prices for each provider in each country. This procedure effectively estimates what each provider's price would be for each of the six standardized broadband products in each country if broadband demand, cost, network quality, and content quality were at the levels observed in the United States.[110] We then aggregate these provider-specific price predictions

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variables that we can include in the analysis, our results should still be interpreted with caution when comparing country rankings.

[107] The *Sixth International Broadband Data Report* described in detail how each of these factors would be expected to affect international price comparisons and why these should be accounted for when comparing prices across countries. *See Sixth International Broadband Data Report*, 33 FCC Rcd at 980-81, paras. 5-6; *see also id.* at 1023-27, paras. 7-13.

[108] U.S. Bureau of Labor Statistics, *Quality Adjustment in the CPI*, https://www.bls.gov/cpi/quality-adjustment/home.htm (last modified Sept. 15, 2022) (last visited Oct. 6, 2022).

[109] In a standard hedonic broadband pricing analysis, a country fixed effect would be included to account for country-level differences in cost and demand factors. However, since the country fixed effect is used to predict prices, these cost and demand differences remain in the predicted price levels. Our approach differs by decomposing the fixed effect into observable cost components and an unobserved random effect to remove the effect of exogenous country-level observable cost and demand differences from predicted prices.

[110] Fixed broadband product prices are predicted at the following download speeds for both standalone and bundled plans: 100 Mbps, 250 Mbps, and 1 Gbps. All other fixed broadband plan characteristics are the same in order to make prices comparable across countries. The other features of the plans used to predict prices are as follows: no contract, no fixed voice service, symmetric upload and download speeds, and an unlimited data usage allowance. The mobile broadband products are predicted at the following data allowances for both single-line and multi-line
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for each of the six products by using U.S. product share weights and the previously described Laspeyres price index formula, to arrive at the price that U.S. consumers would have to pay in each country for their broadband services if those countries had U.S. broadband cost, quality, and demand conditions.

D. Fixed Broadband Pricing Analysis and Results

76. *Fixed Broadband Price Index.* In Figure 41 below, we present country rankings based on the fixed broadband price index, as well as this index divided by the average monthly data usage per subscriber to calculate a unit price measured in dollar per gigabyte of data consumption ($/GB).[111] The United States ranks 24th out of 26 countries in standalone pricing, and the ranking is also at 24th for broadband bundled with video service.[112] Combining standalone and bundled pricing, the overall ranking of the United States is 24th out of 26 countries. On a price per GB of data consumed basis, the United States ranks 7th out of the 22 countries for which we have usage data.[113]

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plans: 10 GB, 25 GB, and 50 GB per line. For the multi-line products, the 10 GB and 25 GB plans have two lines each and the 50 GB plan has three lines. The other plan features for the price predictions are as follows: no contract, no download speed restrictions, unlimited minutes, and unlimited texts.

[111] All reported prices for the broadband index are adjusted using a measure of Purchasing Power Parity (PPP) to make the results comparable to the income-adjusted hedonic index results. Figure 41 presents the weighted average prices in each country for the indicated products. The Laspeyres index for each country would be calculated by dividing the given country's weighted price by the U.S. weighted price. *See infra* Fig. 41.

[112] To calculate the price of broadband for each bundled offering, we first calculate the bundle discount as the difference between the total price of the standalone offerings for each service and the bundle. We then assume that this bundle discount is allocated to each component of the bundle in proportion to the standalone costs of each component. In this manner, we remove the video component price from the broadband bundle price. We also note that the bundle and standalone pricing measures are not strictly comparable in Figure 41 because the plans that are included in each calculation may be different. *See infra* Fig. 41. For this reason, the bundle price in a country may be higher than the standalone price. *See infra* Fig. 50.

[113] Dividing monthly price by data usage may not be appropriate because data consumption affects broadband pricing and broadband pricing also likely affects data consumptions. In other words, data consumption is endogenous with price. *See 2020 Communications Marketplace Report*, 36 FCC Rcd at 3791, Appx. G-3: International Broadband Data Report, para. 16.

Fig. 41. Fixed Broadband Price Indexes (PPP Adjusted)

Country	Standalone		Bundled		Overall		$/GB	
	Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank
Australia	68.30	21	68.30	21	68.30	21	0.23	12
Austria	53.58	9	53.58	12	53.58	11	0.29	19
Belgium	59.27	15	56.75	14	57.73	14	0.24	14
Canada	80.96	25	80.96	25	80.96	25	0.24	15
Czech Republic	51.52	7	48.67	6	49.77	6	0.23	11
Denmark	43.47	3	43.47	3	43.47	3	0.13	3
Estonia	68.14	20	67.66	20	67.84	20		
Finland	54.41	11	52.82	9	53.43	10	0.41	22
France	46.66	4	46.66	4	46.66	4	0.19	6
Germany	49.47	5	48.29	5	48.75	5	0.23	13
Greece	62.14	18	58.21	15	59.73	16	0.40	21
Iceland	73.18	22	73.18	22	73.18	22	0.18	4
Ireland	61.86	17	61.74	18	61.79	18	0.26	17
Italy	42.78	2	42.78	2	42.78	2	0.22	10
Latvia	38.27	1	34.53	1	35.98	1	0.10	1
Luxembourg	67.14	19	67.14	19	67.14	19		
Mexico	74.19	23	74.19	23	74.19	23		
Netherlands	58.11	13	53.01	10	54.98	12	0.31	20
New Zealand	60.98	16	60.98	17	60.98	17	0.21	8
Norway	101.97	26	99.40	26	100.39	26		
Portugal	58.45	14	58.45	16	58.45	15	0.27	18
Spain	50.94	6	50.94	7	50.94	7	0.19	5
Sweden	53.96	10	52.63	8	53.15	8	0.21	9
Switzerland	55.94	12	55.94	13	55.94	13	0.25	16
United Kingdom	53.38	8	53.08	11	53.19	9	0.12	2
United States	**76.46**	**24**	**75.98**	**24**	**76.17**	**24**	**0.20**	**7**

Source: TeleGeography, *GlobalComms Database* (last accessed Feb. 9, 2022); Ofcom, *International Broadband Scorecard 2021: Interactive Data*, https://www.ofcom.org.uk/research-and-data/telecoms-research/broadband-research/eu-bbroadand-scorecard/international-broadband-scorecard-2021-interactive-data (last visited Aug. 31, 2022); International Telecommunication Union, *World Telecommunications/ICT Indicators Database 2022 (26th Edition/July 2022)* (last accessed Sept. 16, 2022).

Note: To make the results comparable to the income-adjusted hedonic analysis, prices are reported in PPP-adjusted U.S. dollars.

77. *Fixed Broadband Hedonic Price Index.* The estimated coefficients for the four fixed broadband hedonic models are shown in Figure 42 below.[114] Before reviewing the estimates, we first note that the estimated coefficients in our models are reduced form estimates of how prices are correlated with product characteristics and country-level factors, so they should not be given a causal interpretation for how we would expect price to change if, for example, the income level of a country increased. Despite this issue, the coefficients generally align with expectations and are often statistically significant.

[114] The estimated random coefficient variances are provided in Figure 52. *See infra* Fig 52.

78. The model estimates that higher speed plans cost more, and the rate of increase in price (i.e., slope) is higher for plans at a higher speed tier.[115] Bundling broadband with other services is estimated to lower the price of the broadband service by approximately 2.3% on average across all countries.[116] The inclusion of unlimited data usage allowance is estimated to increase price by about 3% in all models. For the country-level control variables, we find that the per capita income in a country has a large and statistically significant effect on prices. Population density has a negative coefficient as expected and is statistically significant, while educational attainment has a positive coefficient as expected but is not statistically significant. Our other broadband cost proxy variable, terrain ruggedness, has a large but statistically insignificant effect on fixed broadband prices. In Model 4, we estimate that a 1% increase in terrain ruggedness increases broadband prices by 11%, and this is statistically significant at the 5% level. Finally, as observed in Model 4, the proxy variable for content availability and quality also has a strong positive effect on broadband prices, and this is also significant at the 1% level.

[115] The effect of download speeds on broadband prices is estimated as a piecewise linear spline with three download speed cutoffs. A linear spline allows the estimated coefficients to be different for the range of download speeds between each cutoff. For example, our estimated coefficients imply that the price of fixed broadband increases more steeply for plans with download speeds above 250 Mbps compared to those below 100 Mbps.

[116] When a dependent variable is measured in logarithmic form, the percentage change in the dependent variable for a change in a dummy variable from 0 to 1, or a logged continuous independent variable, is calculated as $100[\exp(\beta) - 1]$. A dummy, or indicator, variable refers to a binary variable that can take only the values 0 and 1. *See, e.g.*, James H. Stock & Mark W. Watson, Introduction to Econometrics 145 (4th ed. 2019).

Fig. 42. Fixed Broadband Hedonic Regressions

Log Average Monthly Price (in U.S. dollars)	Model 1			Model 2			Model 3			Model 4		
	Coef.	SE	*p*	Coef.	SE	*p*	Coef.	SE	*p*	Coef.	SE	*p*
Spline: 0 < Mbps < 100	0.109	0.011	0.000	0.109	0.011	0.000	0.109	0.011	0.000	0.109	0.011	0.000
Spline: 100 ≤ Mbps < 250	0.091	0.038	0.016	0.080	0.038	0.036	0.080	0.038	0.035	0.079	0.038	0.040
Spline: 250 ≤ Mbps	0.258	0.026	0.000	0.257	0.026	0.000	0.257	0.026	0.000	0.257	0.026	0.000
Symmetric Speeds Dummy	-0.041	0.025	0.105	-0.051	0.025	0.044	-0.051	0.025	0.045	-0.048	0.025	0.058
Bundle Dummy	-0.023	0.009	0.009	-0.023	0.009	0.009	-0.023	0.009	0.009	-0.023	0.009	0.009
Fixed Voice Dummy	0.148	0.042	0.000	0.129	0.040	0.001	0.128	0.040	0.001	0.120	0.039	0.002
Unlimited Data Dummy	0.030	0.026	0.255	0.028	0.026	0.287	0.028	0.026	0.288	0.029	0.026	0.263
Log Gross National Income (GNI) Per Capita				0.522	0.088	0.000	0.528	0.092	0.000	0.476	0.082	0.000
Log Non-Rural Population Density				-0.123	0.039	0.002	-0.122	0.040	0.002	-0.100	0.036	0.005
Educational Attainment				1.273	0.704	0.070	1.280	0.705	0.070	0.992	0.634	0.118
Log Terrain Ruggedness Weighted by Population				0.088	0.055	0.107	0.088	0.055	0.108	0.111	0.049	0.024
Coverage (% Households with > 100 Mbps)							-0.081	0.310	0.793	0.066	0.273	0.808
Content Quality (1st Principal Component) (Standardized)										0.093	0.035	0.008
Constant	3.196	0.093	0.000	-1.916	0.832	0.021	-1.929	0.835	0.021	-1.515	0.740	0.041
Number of Observations	960			960			960			960		
Log Likelihood	289.1			308.4			308.5			311.5		
Likelihood Ratio Test vs. Linear Model												
***P*-Value**	0.000			0.000			0.000			0.000		

Note: The estimated random coefficient variances and measures of goodness of fit are provided in Figure 52 of section IV.G.

79. The resulting country rankings under each model are shown in Figure 43 below. This figure reports the overall rankings that aggregate over the three standalone and three bundled products in each country. In Model 1, after adjusting for only broadband plan characteristics, we find that the United States ranks 23rd out of the 26 countries in our sample, with an average broadband price of $69.86. Countries with lower average incomes, like Latvia and the Czech Republic, rank near the top before we correct the price levels for per capita income. In Model 2, after we correct price levels for differences in income, terrain, education, and population density, we find that the United States ranks 13th. The change in ranking from the first model is due to the United States having relatively high income and educational levels and more rugged terrain compared to the other countries in our sample.[117] Model 3 includes the percentage of households with access to download speeds of at least 100 Mbps, and the ranking of the United States remains at 13th. Model 4 adds our content quality proxy variable into the hedonic regression, and results in the United States ranking 5th least expensive out of the 26 countries.

Fig. 43. Fixed Broadband Hedonic Price Indexes

Country	Model 1		Model 2		Model 3		Model 4	
	Price	Rank	Price	Rank	Price	Rank	Price	Rank
Australia	77.22	24	85.03	20	83.38	19	100.26	18
Austria	58.10	16	87.24	21	86.72	21	107.49	20
Belgium	60.23	18	83.89	19	84.20	20	112.23	21
Canada	82.91	25	102.40	25	102.15	25	115.52	22
Czech Republic	32.08	3	66.19	11	66.51	11	81.52	11
Denmark	47.00	10	59.15	6	59.24	6	78.45	10
Estonia	54.88	15	90.20	22	90.23	22	119.43	23
Finland	52.92	13	61.15	8	59.95	7	85.97	13
France	32.27	4	52.56	4	51.64	4	69.00	4
Germany	43.12	8	64.28	9	64.23	9	83.19	12
Greece	45.44	9	94.17	24	92.13	24	121.76	24
Iceland	68.30	22	74.13	15	73.78	15	94.02	15
Ireland	51.01	12	67.79	12	67.29	12	76.22	8
Italy	25.61	2	49.46	2	49.13	2	62.12	2
Latvia	20.71	1	45.16	1	45.43	1	60.70	1
Luxembourg	59.39	17	50.88	3	51.02	3	69.80	6
Mexico	39.56	7	150.42	26	149.74	26	175.84	26
Netherlands	49.30	11	79.41	17	79.69	17	106.95	19
New Zealand	63.55	21	64.54	10	64.47	10	74.34	7
Norway	118.60	26	92.25	23	91.96	23	124.05	25
Portugal	37.14	6	78.44	16	78.99	16	98.38	16
Spain	33.77	5	61.08	7	61.47	8	77.45	9
Sweden	62.03	19	73.24	14	72.93	14	99.27	17
Switzerland	62.84	20	52.66	5	52.70	5	67.57	3
United Kingdom	54.60	14	82.81	18	80.97	18	92.72	14
United States	**69.86**	**23**	**69.34**	**13**	**69.36**	**13**	**69.68**	**5**

[117] *See infra* Fig. 59.

E. Mobile Broadband Pricing Analysis and Results

80. *Mobile Broadband Price Index*. In Figure 44 below, we present the country rankings, including an index for single-line plans, another for multi-line plans, and an overall index that is a weighted average of the single- and multi-line plan indexes.[118] The United States ranks 24th out of the 26 countries in single-line plan pricing at $72.88, and ranks 24th for multi-line pricing at $49.73 per line. Italy ranks 1st in single-line plan pricing and 2nd in multi-line pricing, at $19.10 per line per month and $18.25 per line per month, respectively. Combining single-line and multi-line data plan pricing, the overall ranking of the United States is 24th. Finally, due to the relatively high data usage of U.S. subscribers, on a dollar per GB basis, the ranking of the United States improves to 21st.[119]

[118] The product prices by country that were used in the mobile broadband price index calculations are presented in Fig. 56 of section IV.G and adjusted using a measure of PPP.

[119] The same caveat regarding the potential problems with dividing price by data usage also applies to mobile broadband. However, the plans are now sold by usage allowances. Thus the endogeneity problem may be even worse.

Fig. 44. Mobile Broadband Price Indexes (PPP Adjusted)

Country	Single Line		Multi-Line		Overall		$/GB	
	Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank
Australia	38.35	16	31.39	17	32.85	17	3.55	11
Austria	35.14	14	29.62	14	30.78	12	1.20	2
Belgium	33.37	11	30.20	15	30.87	14	9.05	22
Canada	81.09	26	73.66	26	75.22	26	21.99	26
Czech Republic	37.91	15	35.67	19	36.14	19	11.40	24
Denmark	26.27	6	20.45	3	21.67	4	3.01	9
Estonia	23.66	5	20.68	4	21.30	3	1.33	4
Finland	39.36	19	39.36	20	39.36	20	1.27	3
France	26.42	7	24.70	7	25.07	7	2.58	8
Germany	47.90	21	26.43	9	30.94	15	6.77	18
Greece	52.46	23	44.58	23	46.24	23	13.44	25
Iceland	29.06	8	24.84	8	25.73	8	1.54	5
Ireland	34.43	12	33.74	18	33.88	18	3.56	12
Italy	19.10	1	18.25	2	18.43	2	1.89	6
Latvia	23.32	3	21.73	5	22.07	5	0.96	1
Luxembourg	34.44	13	29.09	13	30.22	11	4.83	14
Mexico	31.13	10	26.92	10	27.80	9	6.14	16
Netherlands	29.69	9	27.44	11	27.91	10	7.52	20
New Zealand	39.27	18	30.94	16	32.69	16	7.11	19
Norway	47.18	20	40.10	21	41.59	21	5.74	15
Portugal	49.85	22	44.17	22	45.37	22	10.19	23
Spain	20.12	2	16.95	1	17.61	1	3.24	10
Sweden	38.49	17	28.74	12	30.79	13	2.57	7
Switzerland	73.43	25	67.91	25	69.07	25	6.57	17
United Kingdom	23.61	4	22.96	6	23.09	6	4.37	13
United States	**72.88**	**24**	**49.73**	**24**	**54.59**	**24**	**7.67**	**21**

Source: OECD, Broadband Portal, https://www.oecd.org/sti/broadband/broadband-statistics/ (last visited Oct. 6, 2022).
Note: To make the results comparable to the income-adjusted hedonic analysis, prices are reported in PPP adjusted U.S. dollars.

81. *Mobile Hedonic Price Index.* The estimated coefficients for the three mobile broadband hedonic models are shown in Figure 45 below.[120] The three models presented in this section mirror the models in our fixed pricing analysis with the exception that the network quality variable now includes measures of both network availability and download and upload speeds. Increasing the number of lines from one to two is expected to decrease the expected price per line by approximately 6.3%. For mobile broadband, the estimated effects of the country-level variables on broadband prices differ from the patterns we observed in our fixed hedonic analysis. Surprisingly, the estimated effect of income (i.e., Log gross national income (GNI) per capita) on mobile broadband prices is negative, but this result is not statistically significant in any specification. However, educational attainment, a measure closely related to income, is found to increase expected mobile broadband prices, and this result is significant at the 5%

[120] The estimated random coefficient variances and measures of goodness of fit are provided in Fig. 57 of section IV.G.

level in Models 2 and 3. Population density is found to have negative and statistically significant effect in Model 3 on mobile broadband prices, while terrain variation in a country has a negative but statistically insignificant effect in Model 2 on mobile broadband prices. As we would expect, higher network quality is associated with higher prices.

Fig. 45. Mobile Broadband Hedonic Regressions

Log Average Monthly Price Per Line (in U.S. dollars)	Model 1			Model 2			Model 3			Model 4		
	Coef.	SE	p	Coef.	SE	p	Coef.	SE	p	Coef.	SE	p
Number of Lines	-0.019	0.006	0.001	-0.019	0.006	0.001	-0.019	0.006	0.001	-0.019	0.006	0.001
Family Plan Dummy	-0.044	0.028	0.124	-0.044	0.028	0.122	-0.044	0.028	0.121	-0.044	0.028	0.122
Log Data Cap	0.254	0.024	0.000	0.250	0.025	0.000	0.250	0.025	0.000	0.253	0.024	0.000
Unlimited Data Dummy	-0.356	0.090	0.000	-0.357	0.088	0.000	-0.357	0.087	0.000	-0.358	0.088	0.000
Log Download Speed	0.035	0.023	0.131	0.013	0.024	0.590	-0.002	0.025	0.951	0.016	0.023	0.499
Unlimited Download Speed Dummy	0.058	0.042	0.165	0.067	0.041	0.104	0.074	0.041	0.070	0.072	0.040	0.076
5G Technology Dummy	0.111	0.020	0.000	0.108	0.019	0.000	0.108	0.019	0.000	0.106	0.019	0.000
Unlimited Minutes Dummy	-0.254	0.285	0.373	-0.199	0.281	0.480	-0.191	0.279	0.494	-0.175	0.278	0.527
Unlimited Text Messages Dummy	0.115	0.085	0.177	0.110	0.085	0.196	0.105	0.085	0.215	0.103	0.085	0.227
Log GNI Per Capita				-0.064	0.269	0.812	-0.294	0.236	0.214	-0.435	0.242	0.072
Educational Attainment				3.919	1.651	0.018	3.754	1.270	0.003	3.077	1.300	0.018
Log Country Population Density				-0.199	0.073	0.006	-0.194	0.064	0.002	-0.117	0.070	0.095
Log Terrain Ruggedness Weighted by Population				-0.107	0.148	0.468	-0.287	0.129	0.026	-0.133	0.133	0.316
Network Quality (1st Principal Component) (Standardized)							0.315	0.106	0.003	0.398	0.117	0.001
Content Quality (1st Principal Component) (Standardized)										0.178	0.089	0.045
Constant	2.548	0.302	0.000	2.927	2.690	0.277	5.296	2.397	0.027	6.624	2.433	0.006
Number of Observations	1801			1801			1801			1801		
Log Likelihood	175.0			180.8			183.5			185.2		
Likelihood Ratio Test vs. Linear Model												
P-Value	0.000			0.000			0.000			0.000		

Note: The estimated random coefficient variances and measures of goodness of fit are provided in Fig. 57 of section IV.G.

82. Our hedonic price indexes based on the four estimated hedonic regressions are provided in Figure 46. For mobile broadband service, adjusting for cost and demographic factors does not have as large of an impact on the ranking of the United States as we observed for fixed broadband service. In Model 1, before adjusting for income, terrain, educational attainment, and population density factors, the United States ranks 23rd among the 26 countries in mobile broadband pricing. Correcting for these factors in Model 2 changes the U.S. ranking to 13th. Adding the network performance measures in Model 3 improves the U.S. ranking to 12th. And finally, the United States ranks 8th in mobile broadband pricing after adding the content quality proxy measure in Model 4.

Fig. 46. Mobile Broadband Hedonic Price Indexes

Country	Model 1		Model 2		Model 3		Model 4	
	Price	Rank	Price	Rank	Price	Rank	Price	Rank
Australia	35.22	16	28.85	4	29.19	4	42.14	4
Austria	40.39	19	124.64	25	163.20	26	198.63	26
Belgium	43.68	21	59.20	16	58.89	17	89.90	21
Canada	74.00	25	59.61	17	51.78	13	68.74	13
Czech Republic	37.92	17	85.60	23	63.94	20	73.09	15
Denmark	22.81	4	33.63	7	25.66	3	37.17	3
Estonia	26.90	7	33.45	6	33.74	6	49.34	5
Finland	30.38	13	35.17	9	33.95	7	52.98	9
France	27.36	8	60.93	21	72.42	22	100.96	23
Germany	29.62	12	59.82	18	59.02	18	82.35	18
Greece	38.21	18	61.62	22	69.45	21	86.91	20
Iceland	30.97	14	25.38	2	24.93	2	37.08	2
Ireland	19.57	1	24.07	1	39.67	9	58.40	12
Italy	19.91	2	60.62	20	74.92	23	93.13	22
Latvia	24.73	6	28.73	3	29.96	5	49.43	6
Luxembourg	41.75	20	58.76	15	63.02	19	85.55	19
Mexico	53.43	24	126.00	26	152.25	25	179.36	25
Netherlands	28.61	9	37.68	11	21.70	1	32.58	1
New Zealand	33.52	15	37.03	10	44.39	11	56.12	11
Norway	51.49	22	60.46	19	52.17	14	73.28	16
Portugal	29.57	11	54.32	14	56.66	15	71.05	14
Spain	22.59	3	45.02	12	58.29	16	78.14	17
Sweden	28.97	10	34.28	8	34.27	8	55.10	10
Switzerland	74.03	26	97.54	24	99.67	24	118.73	24
United Kingdom	23.56	5	31.85	5	40.73	10	50.52	7
United States	**51.89**	**23**	**51.82**	**13**	**51.66**	**12**	**51.91**	**8**

F. Data and Methods Technical Details

83. This section provides the technical details of how the pricing data were collected and constructed and how other data sources and analysis variables were constructed, along with the mathematical formulas for the empirical estimation of the hedonic broadband price index.

1. Data Collection and Variable Construction

a. Fixed Broadband Pricing Data Collection

84. For each fixed broadband provider, we recorded each combination of download speed, upload speed, data usage allowance, and technology. For example, if a provider offers (1) a fiber-based plan with 100 Mbps download, 100 Mbps upload, and no data cap; (2) a fiber-based plan with 100 Mbps download, 50 Mbps upload, and no data cap; and (3) a cable-based plan with 100 Mbps download, 100 Mbps upload, and no data cap, we record three separate plans.[121] We collected both standalone broadband plans as well as double play packages of broadband bundled with multichannel video services.[122] With some exceptions, we did not collect information on "triple play" bundles of fixed voice phone, Internet, and video because the extent of the bundle discount received did not tend to increase with the addition of phone service, and doing so would have greatly increased the data collection burden.[123] In cases where a provider only offered Internet service to customers who also subscribed to fixed voice phone services, we collected Internet bundled with fixed voice phone service plans and any relevant bundled plans of Internet, fixed voice phone service, and television.[124] In such cases, we collected triple play bundles from the provider that included the particular phone plan to isolate the bundled broadband price using the methodology described below. Finally, if the provider did not offer video service, bundle discounts, or standalone TV plans, we did not collect bundled plans for the particular download speed, upload speed, data usage allowance, and technology combinations for the provider.

85. Given the large number of countries, providers, and plan offerings, we limited the scope of the collection along several additional dimensions. First, we assumed customers were new to the provider and did not receive any special discounts that were not available to all new customers (e.g., student discounts). Second, we only recorded information for the combination of features that resulted in the lowest price for a given plan.[125] For example, we did not include optional add-on features (e.g., HBO, security software, etc.), always chose the lowest priced equipment required for the plan, and assumed consumers were willing to sign up for a two-year contract if this offered the lowest price.[126] Also, we did not include any plans with spectrum-based technologies (e.g., fixed wireless, satellite, 4G).

86. We collected three types of data for each plan: (1) general information, (2) pricing data, and (3) non-pricing data. General information captures information such as the name of the plan, date of collection, and the currency used for the collected prices. For pricing data, we collected all pricing information available on the provider's website including promotions, equipment fees, installation fees, and rebates to calculate the total cost of the broadband service plan over a two-year time horizon. Non-pricing data includes information such as download and upload speeds, data usage allowances, number of

[121] Prior data collections for the *2020 International Broadband Data Report* did not collect plans with download speeds greater than 1 Gbps. For this *Report*, we have recorded such plans when available.

[122] By multichannel video services, we mean linear television packages usually offered using cable, satellite, or Internet with regularly scheduled programs. OTT services, which stream programs to specific users, that are bundled with a broadband plan are not considered in our analysis and thus are unobserved product characteristics if they are included in any plans.

[123] Additionally, we did not collect fixed broadband plans bundled with mobile voice and data services.

[124] In cases where fixed voice phone plans are bundled in the plan, we always chose the lowest priced fixed voice phone package and indicated that fixed voice phone service is included in the bundled plan.

[125] Essentially, if a provider offered multiple plans that would have appeared identical within our data framework, we recorded the lowest priced plan. This approach would exclude any optional add-on services that do not affect download speed, upload speed, or data allowance.

[126] More generally, if a provider offered the same plan with different contract length options with discounts for longer contracts, we chose the longest contract length available (up to 24 months).

channels (if applicable), and contract length. A unique plan is defined by country, city, provider, broadband plan, TV plan, phone service, technology, download speed, upload speed, and data allowance.

87. *Data Review and Cleaning Process.* Upon completion of the data collection, we reviewed the data for accuracy and completeness. When the variables essential for the analysis were unavailable, we made the following assumptions to impute the missing data:

- When generally advertised download speeds were not reported, but providers displayed address-specific download speeds, we used the average download speed across sampled addresses for which the plan was available.
- If upload speeds were not advertised, we assumed that the upload and download speeds were asymmetric.[127]
- If the provider's website did not list a data allowance, we assumed the plan offered an unlimited data allowance.[128]
- If a plan advertised a promotional price without specifying duration, we assumed the promotion lasted one month.
- If the regular monthly price was not found, we assumed that the last available promotional price stayed in effect for the remaining period.
- If equipment prices were not available, we assumed the relevant equipment was included.[129]
- If activation fees, installation fees, and other recurring and non-recurring fees and rebates were not listed clearly on a provider's website, we assumed that these fees were included or did not apply to the plan.
- For Canada and the United States, if taxes were not explicitly stated as included in the list prices and not reported separately, we added a percentage to the total pre-tax prices.[130] For all other countries, we assumed taxes were included.[131]

88. We also made two other assumptions that apply to only two specific providers:

- For one of the providers in Iceland that did not display download speeds, we assumed the same download speed as all of the plans offered by two other providers in Iceland (i.e., 1 Gbps). In Iceland, plan prices varied by data usage allowance, not download speed.

[127] For plans with known download and upload speeds, we consider plans with upload speeds that are at least 80% of their download speeds as being effectively symmetric when defining the symmetric speeds dummy variable for the hedonic analysis.

[128] We top coded monthly data allowances to 2000 GB so that any plans with at least 2000 GB per month were considered unlimited.

[129] Equipment refers to a modem/router for broadband service and a set top box (STB) for television service, if applicable.

[130] International Telecommunication Union, *World Telecommunications/ICT Indicators Database 2020 (24th Edition/July 2020)* (last accessed Aug. 31, 2022). We do not provide URLs for ITU data throughout this section because it is a paid subscription service that cannot be publicly accessed.

[131] With the exception of the United States and Canada, most providers in other countries note that list prices included taxes such as value added taxes (VAT). Providers in the United States and Canada generally displayed prices that did not include taxes. In some cases, taxes were not included in prices but were reported separately, in which case we were able to add the reported tax (i.e., we did not apply a percentage of the pre-tax total price to estimate the tax).

- For one of the providers in Greece that did not advertise speeds for its Asymmetric Digital Subscriber Line (ADSL) plan, we assumed the same download speed as the ADSL plan of another provider in Greece (i.e., 24 Mbps).

89. *Fixed Broadband Price Calculation*. After cleaning the data, we calculated the total cost of each plan over the first 24 months. A 24-month price was selected to produce a comparable pricing measure across plans that accounted for all promotional and regular pricing and to amortize one-time fees over a sufficiently long-term horizon. This total 24-month price was calculated using the formula below.

$$\begin{aligned} Price_{24Month} = {} & (PromoPrice_1 * PromoDuration_1) + (PromoPrice_2 * PromoDuration_2) \\ & + (24 - PromoDuration_1 - PromoDuration_2) * NonPromoPrice + 24 \\ & * (ModemPrice + STBPrice - RebateMonthly + OtherMonthly + Tax) \\ & + InstallationFee + ActivationFee - RebateOneTime + OtherFees \end{aligned}$$

90. We then divided this price by 24 months to calculate the average monthly price. We converted all currencies to U.S. dollars using PPP for the broadband price index and Currency Exchange Rate conversion factors for the hedonic price index.[132]

91. As noted above, U.S. consumers often purchase fixed broadband and video service in a bundle at discounted rates. Furthermore, it is very difficult to compare multichannel video products across countries. The product offerings in terms of channels included are completely different across countries, and the same content may be highly watched in some countries (e.g., American football in the United States) but not of great interest to most viewers in another country (e.g., American football in Europe). Therefore, unlike broadband, where a download speed of 25 Mbps is a product characteristic in which more of the characteristic is always better (i.e., vertical characteristics), there is no standardized video product that would be comparable across countries by holding consumer utility fixed. Given that many studies attempt to control for video quality differences based on observable product characteristics and because we do not believe the observable measures adequately capture quality differences across countries, we therefore calculate a bundle discount and allocate this across the standalone component pricing to isolate the price of broadband when purchased in a bundle.

92. To calculate this bundled discount, we matched all bundled plans with their corresponding standalone Internet and standalone video component plans to calculate a bundle discount percentage. The formula below calculates the bundle discount percentage D_B based on the standalone Internet price P_I, the standalone video price P_V, and the bundle price P_B. For many bundled plans, we were able to collect the exact corresponding standalone Internet and video component plans.

$$D_B = \frac{(P_I + P_V) - P_B}{(P_I + P_V)} = \left(1 - \frac{P_B}{P_I + P_V}\right)$$

93. After calculating the discount percentage from the standalone Internet and standalone video prices for each bundled plan, we applied the percentage equally to the standalone broadband and video component plan prices to arrive at the implied price of broadband when purchased in a bundle.[133] To illustrate, suppose the standalone prices for a particular video and Internet broadband plan are $100 and $50, respectively, but the two can be purchased in a bundle for $120. Then the bundle discount

[132] OECD, *Purchasing power parities (PPP)*, https://data.oecd.org/conversion/purchasing-power-parities-ppp.htm (last visited Oct. 6, 2022); OECD, *Exchange rates*, https://data.oecd.org/conversion/exchange-rates.htm#indicator-chartt (last visited Oct. 6, 2022). The hedonic index already corrects for income and price level differences across countries through the inclusion of a country income variable in the regression and does not need further adjustments for purchasing power parities.

[133] Allocating the bundle discount percentage equally to each of the standalone components is equivalent to allocating the bundle discount amount in proportion to the standalone component prices.

percentage is 20% and the implied price of the video plan when purchased in a bundle is $80, while the implied price of broadband when bundled is $40. This implied broadband price when bundled and the associated broadband characteristics would then be included as a plan in the dataset. In this manner, our analysis does not compare video and broadband bundles across countries but rather isolates an implied price of broadband when bundled to avoid video product comparability issues across countries.

94. However, for bundled plans without corresponding standalone Internet plans and for standalone Internet plans without corresponding bundled plans, we created "synthetic plans" with the same product characteristics but with a price to set the bundle discount equal to zero. Synthetic plans that correspond with collected bundled plans may represent bundled plans that could be available without a bundle discount (i.e., add-on pricing).

95. In Figure 49, we present country-level average bundle discounts over all bundled plans (including synthetic plans). First, we take a simple unweighted average of the bundle discount and bundle discount rates over all plans for each provider's product categories. Then, we aggregate over providers, weighted by their market shares. Finally, we aggregate over country-level products using the download speed tier shares to arrive at our bundle discount estimate for each country. The results of this analysis confirm that bundling discounts vary widely across countries, and therefore accounting for product bundling is important in order to accurately reflect the prices actually paid by consumers for broadband services in each country.

b. Mobile Broadband Pricing Data Collection

96. We collected mobile plan information in three broad categories: (1) general information including country, provider, plan name, and date of collection, (2) pricing information including all types of recurring and non-recurring costs such as promotional prices, activation fees, and rebates, and (3) non-price information, such as data usage allowance and number of minutes and text messages (if not unlimited).[134] We only collected plans available online and to new customers without any special discounts (e.g., student discounts). A unique plan is defined by the country, provider, technology, data allowance, maximum download speed, number of lines, number of minutes, and number of text messages.[135]

97. We sought to collect pricing information excluding the cost of handsets due to both the complexity that handsets introduce in measuring price and the fact that most providers allow customers to bring their own devices. Generally, providers either sold handsets separately from the service plan and/or allowed customers to bring their own devices (i.e., customers received a SIM card from the provider). Although handsets are a significant portion of the cost of mobile broadband services, we chose not to consider these costs to keep prices comparable across countries.

98. One of the most important price factors for mobile broadband service is the data usage allowance.[136] We recorded the monthly data allowance for each plan.[137] In general, providers set a "soft"

[134] All price variables are recorded as the total for all lines for the plans (i.e., not on a per-line basis).

[135] Regarding contract durations, one minor change in the mobile pricing collection for this *2022 IBDR* from the *Sixth International Broadband Data Report* and the *2020 International Broadband Data Report* is that this *2022 IBDR* only collected the least expensive (usually the longest) contract (up to 24 months) option per plan. These prior data collections for the *Sixth International Broadband Data Report* and *2020 International Broadband Data Report* recorded separate plans for different contract durations (e.g., month-to-month, 12-month, 24-month contracts). This *2022 IBDR*, as well as the *Sixth International Broadband Data Report* and *2020 International Broadband Data Report*, did not collect all possible mix-and-match combinations of plans. For example, a provider may offer a 5 GB plan that can be combined with a 2 GB plan for a discount, but the Reports only collected multi-line plans of identical data allowances.

[136] We only consider data that can be consumed within the customer's country. In some cases, particularly the plans offered by providers in Europe, customers can use the main data allowance in several countries and/or have a

(continued….)

data allowance per month before the provider imposes a consequence for exceeding the usage allowance.[138] If a customer exceeds the allowance, the provider *may* decrease mobile broadband speeds for the remainder of the month, charge overage fees (i.e., a consumer pays for additional data use), or stop service entirely (i.e., a "hard" data limit). The structure of the data allowance policies varies by provider and can be quite complex; therefore, we no longer collect the data cap consequence variable in our data collection.[139]

99. We encountered a few issues unique to a small number of providers that required making assumptions about customer preferences. For providers that offered a plan with a set number of units to allocate between talk and text messages, we split these equally across the services and recorded the exchange rate among the services (e.g., 1 unit = 1 minute = 1 text).[140] If a provider offered multiple plans that would appear identical within our data framework, we recorded the least expensive of these plans.[141]

100. Since the *2020 International Broadband Data Report's* Mobile Broadband Pricing Data collection, several trends in plans have emerged that we attempt to address in our latest data collection and analysis. Although many providers continue to offer plans that are generally differentiated by data allowances, some providers now offer plans differentiated by maximum download speeds, video streaming quality restrictions, streaming services, or other product characteristics. Also, with the introduction of 5G networks in many countries, some providers differentiate plans by restricting access to 5G to more expensive plans.[142] Similarly, more and more providers are differentiating plans by maximum download speeds, for both limited data plans and unlimited data plans.[143] To address these trends, we collected the technology (e.g., 4G or 5G) associated with the plan, the maximum download speed (if any), and the video streaming quality limit.

101. *Data Review and Cleaning Process.* After completing the data collection, we reviewed the data for any issues. When certain essential variables were missing, we made the following assumptions to complete the analysis:

- If a provider advertised some but not all plans as 5G plans, we assumed that the plans not marketed as 5G were restricted to the provider's 4G network. If a provider did not explicitly advertise plans as 4G or 5G, we relied upon Opensignal 5G availability data to indicate

(Continued from previous page)
separate international data allowance included in the base plan. International data allowances are not considered in our analysis because each provider has different policies regarding international data usage.

[137] We do not consider promotional (i.e., limited time) data allowances unless the data allowances are included indefinitely.

[138] In our analysis, "unlimited" is reserved for plans that have at least 50 GB per line per month before there is a consequence imposed.

[139] For example, some providers have several data allowance thresholds with different consequences for exceeding each one, while other providers limit the amount of extra data a customer can buy. Some providers allow customers to choose from various data allowance consequences, thus there is no clear default data cap consequence.

[140] Providers in Luxembourg typically have this structure for units of minutes and text messages.

[141] For example, a provider may offer an Unlimited Talk/Text plan with 50 GB of data with varying levels of international data or with or without a streaming service included. As we do not have variables for international data or other services, we recorded the least expensive of these plans.

[142] The mobile pricing data collection of prior International Broadband Data Reports explicitly did not collect plans marketed as 5G plans, given that deployment of 5G networks was very limited across countries and within countries.

[143] *See 2020 Communications Marketplace Report*, 36 FCC Rcd at 3812, Appx. G-3: International Broadband Data Report, para. 62 (discussing plans with explicit download speed restrictions in the prior mobile pricing data collection).

whether the provider had deployed 5G or not and assumed that either all plans were restricted to 4G or all plans could access 5G where available.[144]

- If a provider did not explicitly advertise a maximum download speed restriction for some or all plans, we assumed that the provider allowed consumers to achieve the maximum possible download speed for these plans, potentially before exceeding the data cap.[145] If providers listed a general expected maximum download speed for all plans or all plans on a given technology, we recorded that maximum download speed for all such plans.[146]
- If a plan did not include any text messages (i.e., pay-as-you-go), we set the number of text messages equal to one.[147]
- If a plan advertised a promotional price without specifying the duration, we assumed the promotion lasted one month.
- If the regular monthly price was not found, we assumed that the last available promotional price stayed in effect for the remaining period.
- If activation fees, access fees, other recurring and non-recurring fees, and rebates were not listed clearly on a provider's website, we assumed that these fees were included or did not apply to the plan.
- For Canada and the United States, if taxes were not explicitly stated as included in the list prices and not reported separately, we added a percentage to the total pre-tax prices.[148] For all other countries, we assumed taxes were included.[149]

102. *Mobile Broadband Price Calculation.* After cleaning the data, we then calculated the total cost of each plan over the first 24 months. A 24-month price was selected to produce a comparable pricing measure across plans that accounted for all promotional and non-promotional pricing and to amortize one-time fees over a sufficiently long-term horizon. This total 24-month price was calculated using the formula below:

[144] Of the eight providers where unknown technology was recorded for all plans, we used Opensignal data to set seven providers' plans to 4G plans and one provider's plans to 5G. *See* Opensignal, *Market Insights*, https://www.opensignal.com/market-insights (last visited Oct. 6, 2022) (navigate to a specific country's page within the Opensignal website and click on "Mobile Network Experience" or both "Mobile Network Experience" and "Mobile 5G Network Experience" to obtain data for that country's providers).

[145] The three providers in the United States restrict video streaming quality of their less expensive unlimited data plans. Since these providers do not have explicit maximum download speeds but do restrict video streaming quality (with video streaming being the most data intensive use for most consumers), we use the providers' video streaming quality limits as a proxy for maximum download speeds for such plans. For plans that are restricted to Standard Definition (SD) video streaming, we set the maximum download speed to 3 Mbps; for plans restricted to 720p video streaming, we set the maximum download speed to 8 Mbps. The plans that displayed higher video streaming quality (e.g., 4K Ultra High Definition (UHD)) were set to have no maximum download speed restriction.

[146] We top coded the maximum download speed to 1 Gbps and also top coded data usage allowances to 500 GB per line per month and classified any speeds and allowances as unlimited.

[147] Two of the providers in Spain did not include any text messages with their plans and required pay-per-text. Generally, we top coded both the number of text messages and the number of minutes to 10,000 per month per line.

[148] International Telecommunication Union, *World Telecommunications/ICT Indicators Database 2020 (24th Edition/July 2020)* (last accessed Aug. 31, 2022).

[149] In many countries, providers explicitly stated that taxes (e.g., VAT) were included in prices.

$$Price_{24Month} = (PromoPrice_1 * PromoDuration_1) + (PromoPrice_2 * PromoDuration_2) + (24 - PromoDuration_1 - PromoDuration_2) * NonPromoPrice + 24 * (AccessFee - RebateMonthly + OtherMonthly + Tax) + ActivationFee - RebateOneTime + OtherFees$$

103. Next, we divided the price by the number of lines in the plan to get the total 24-month price per line. Then, we divided the price per line by 24 months to calculate the average monthly price per line. We converted all currencies to U.S. dollars using PPP for the broadband price index calculations and Currency Exchange Rate conversion factors for the hedonic price index.[150]

104. Similar to our fixed broadband analysis, we also created mobile broadband synthetic plans from collected plans when a provider did not offer a particular plan at a discounted price for bundling additional lines, up to four lines.[151] The simplest example is when a provider offers only a single-line plan without any discounts for bundling more lines; in this example, we would create a 2-line synthetic plan, a 3-line synthetic plan, and a 4-line synthetic plan with the same product characteristics and price per line (i.e., no bundle discount relative to the single-line plan). As a slightly more complex example, suppose a provider offers a plan as a single-line plan and a 2-line plan but offers no discount for three or four lines. In this example, we create a synthetic 3-line plan with the per line price set to a weighted average of the single-line and 2-line plan prices (i.e., the total price of purchasing a 2-line plan and a single-line plan divided by three) and a synthetic 4-line plan with the per line price set to the per line price of the 2-line plan (i.e., the total price of purchasing two 2-line plans divided by four). We made other similar synthetic plan calculations for plans that are not available with bundle discounts, with up to four lines, but in all cases synthetic plans are plan combinations that consumers are able to purchase from the provider.[152]

105. In Figure 54, we present country-level average mobile broadband bundle discounts (relative to single-line plans).[153] The calculations include all plans (including synthetic plans), except for plans that do not have a single-line option. We calculated the bundle discount relative to the corresponding single-line plan, and then we took a simple unweighted average of the bundle discount and bundle discount rate over all plans for each provider's product categories. We then aggregated over providers, weighted by their market shares. Finally, we aggregated over country-level products using the bundled data usage product shares. We again find that bundle discounts vary widely across countries and must be accounted for to properly measure the prices that consumers are paying for their mobile services

[150] OECD, *Purchasing power parities (PPP)*, https://data.oecd.org/conversion/purchasing-power-parities-ppp.htm (last visited Oct. 6, 2022); OECD, *Exchange rates*, https://data.oecd.org/conversion/exchange-rates.htm#indicator-chart (last visited Oct. 6, 2022). The hedonic index already corrects for income and price level differences across countries through the inclusion of a country income variable in the regression and does not need further adjustments for purchasing power parities.

[151] To count as the same plan (ignoring the number of lines), the provider must clearly indicate that each line on the plan receives the same services on a per line basis. If a plan includes shared minutes, text, or data, then the plan would be counted as a different plan since the per line minutes, text, or data decrease per line with additional lines. Less common plans where per line data increase with more lines (e.g., bonus data for bundling lines) count as different plans.

[152] In some cases where a provider does not offer a single-line plan, we cannot calculate some combinations of the number of lines. For example, if a plan was only offered as a 2-line plan, then we would calculate a 4-line plan price with the same per line price as the 2-line plan, but we would not have corresponding single-line and 3-line plans.

[153] In some cases, a plan may change data usage tiers (and thus product definition) as the number of lines increases. For example, if a provider offers a 12 GB single-line plan that allows a customer to add lines to the plan and share the data allowance, we classify the single-line plan with 12 GB in the 10 to 25 GB data usage (per line) tier and the 2-line plan with 6 GB per line in the 0 to 10 GB data usage (per line) tier.

in each country. Many countries, such as the United States, offer large bundle discounts when multiple lines are purchased, but some other countries offer no discounts.

c. Variable Construction

106. *Fixed Product Shares.* To calculate the U.S. quantity weights for each of the six products in our price indexes, we use the FCC Form 477 data to estimate the share of U.S. broadband subscribers that subscribe to each of the three broadband download speed tiers and an estimate from S&P Global that about 61% of all U.S. broadband subscribers purchase their service in a bundle.[154] The resulting broadband products and their estimated U.S. market shares are shown in Figure 39 above.

107. *Mobile Product Shares.* In the *2020 International Broadband Data Report*, we used the *Cisco White Paper* to estimate the mobile product shares by assuming that data usage follows a log-normal distribution and using Cisco's estimates of data usage per line for single line and multi-line plans.[155] Because Cisco has not released more recent data, in order to update the mobile product shares, we assume that the shape (standard deviation) of the log-normal distribution has not changed but that the distribution has been translated to the right due to an increase in average data usage over time. To estimate how far the distribution has been translated, we use the *Ericsson Mobility Visualizer* data usage estimates for North America to calculate the percentage change in mobile data usage between 2020 and 2022.[156] We then apply this percentage change to the previous Cisco estimates of data usage per line on single-line and shared data plans to recalculate the mean of the log-normal distribution using our previous methodology.[157]

108. The log-normal distribution has been shown to approximate consumer usage over nearly every communications network, including broadband.[158] This simplifies the estimation of the distribution of data usage because a log-normal distribution is entirely determined by only two parameters: a location parameter that pins down the mean and a scale parameter that determines the shape of the usage distribution.[159] Another important property of the distribution is that percentiles are preserved if the mean

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[154] S&P Global, *Estimated broadband-only homes as a percentage of wireline broadband households, Q1'19-Q4'21*, (last accessed July 18, 2022). We use preliminary FCC Form 477 subscriber data as of December 2021 for these calculations. We again note that the year-end FCC Form 477 data are subject to corrections as appropriate by the service provider, and the final data will be published in due course by the agency.

[155] *2020 Communications Marketplace Report*, 36 FCC Rcd at 3814-15, Appx. G-3: International Broadband Data Report, paras. 69-70, Fig. G-31.

[156] Specifically, Ericsson reports an increase of North American smartphone monthly data usage from to 12.09 GB in 2020 to 18.87 GB in 2022, which is an increase of 56%. *See* Ericsson, *Ericsson Mobility Visualizer*, https://www.ericsson.com/en/reports-and-papers/mobility-report/mobility-visualizer?f=1&ft=2&r=2,3,4,5,6,7,8,9&t=1,2,3,4,5,6,7&s=4&u=1&y=2021,2027&c=3 (last visited Oct. 6, 2022) (to view the specific data, choose mobile data traffic per device per month for North America for smartphones only).

[157] Cisco reports that the overall North American Tier 1 operator average monthly mobile data usage in May 2019 was 12.25 GB, the single-line average mobile data usage was about 14 GB, and for 2-line, 3-line, and 4-line plans, the average monthly data usage was about 10 GB. Based on the 56% increase between 2020 and 2022 reported by the Ericsson data, we estimated that the overall mobile data usage is 19.11 GB; 21.84 GB for single-line plans; and 15.6 GB for multi-line plans.

[158] Ioannis Antoniou et al., *On the log-normal distribution of network traffic*, 167 Physica D: Nonlinear Phenomena 72 (2002).

[159] *See* George S. Ford, *Approximating the Distribution of Broadband Usage from Publicly-Available Data*, 12-03 Phoenix Center Policy Perspective 1 (2012). A random variable is log-normally distributed if the logarithm of the variable is normally distributed.

of the distribution is shifted up or down.[160] Combining the Cisco data with a log-normal distribution assumption, we are able to estimate the percentage of subscribers in the United States that have usage between the data usage allowances of our standardized mobile broadband products. The parameter estimates of this approach are summarized in Figure 47 below.

Fig. 47: Mobile Broadband Data Usage Shares Parameter Estimates

Distribution Parameters			
Plan Type	**Mean (GB)**	**Mu**	**Standard Deviation**
Overall	19.11	2.29	1.15
Individual	21.84	2.42	1.15
Shared	15.60	2.09	1.15

109. *PPP.* To convert pricing data collected in local currency (LCU) to U.S. dollars, we use the OECD's 2021 PPPs which are defined as "the rates of currency conversion that try to equalize the purchasing power of different currencies, by eliminating the differences in price levels between countries. The basket of goods and services priced is a sample of all those that are part of final expenditures: final consumption of households and government, fixed capital formation, and net exports."[161]

110. *Exchange Rates.* To convert pricing data collected in LCU to U.S. dollars, we also use the OECD's 2021 exchange rates which are defined as "the price of one [country's] currency in relation to another country's currency."[162]

111. *Gross National Income Per Capita.* The GNI per capita data are used as a demographic control variable in the hedonic regression models and are from the World Bank.[163] We use 2020 values for each country because 2021 values are not available for Luxembourg. The World Bank defines GNI as the "sum of value added by all resident producers plus any product taxes (less subsidies) not included in the valuation of output plus net receipts of primary income (compensation of employees and property income) from abroad" and converts it to U.S. dollars using a special Atlas method of conversion used by the World Bank.[164]

112. *Educational Attainment.* These data are used as a demographic control variable in the hedonic regression models and are from the OECD.[165] We used the 2020 percentage of 25 to 64-year-olds with Bachelor's (or equivalent education), Master's (or equivalent education), or Doctoral (or equivalent education) degrees to account for educational attainment, except for Denmark where the most recently available values were from 2019.

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[160] *See* George S. Ford, *Approximating the Distribution of Broadband Usage from Publicly-Available Data*, 12-03 Phoenix Center Policy Perspective 1 (2012).

[161] OECD, *Purchasing power parities (PPP)*, https://data.oecd.org/conversion/purchasing-power-parities-ppp.htm (last visited Oct. 6, 2022).

[162] OECD, *Exchange rates*, https://data.oecd.org/conversion/exchange-rates.htm#indicator-chartt (last visited Oct. 6, 2022).

[163] The World Bank, *GNI per capita, Atlas method (current US$)*, https://data.worldbank.org/indicator/NY.GNP.PCAP.CD (last visited Oct. 6, 2022).

[164] The Atlas method applies a conversion factor that averages the exchange rate for a given year and the two preceding years, adjusted for differences in rates of inflation between the country and countries in the Euro area, Japan, the United Kingdom, and the United States. The World Bank, *GNI per capita, Atlas method (current US$)*, https://data.worldbank.org/indicator/NY.GNP.PCAP.CD (last visited Oct. 6, 2022). The World Bank uses this method to account for exceptionally large margins from the official exchange rate and the rate actually applied in international transactions. *Id.*

[165] OECD, *OECD.Stat*, https://stats.oecd.org/ (last visited Oct. 6, 2022).

113. *Non-Rural Population Density.* For the fixed broadband hedonic analysis, we construct a measure of non-rural population density by using four OECD datasets: (1) National Population Distribution (NPD),[166] (2) National Area Distribution (NAD),[167] (3) land area, and (4) population. The NPD is the percentage of the population living in three categories of population density: urban, intermediate, and rural areas. The NAD is the percentage of the area in three categories: urban, intermediate, and rural. The NPD and NAD data are from 2014; therefore, we multiply the percentages by the 2014 population and 2014 land area, respectively, to obtain the total population and total land area in each category. Then, we divide the total population in the three population density categories by the total land area in that category. Non-rural population density is the sum of urban and intermediate population divided by the sum of urban and intermediate land area.

114. *Population Density.* For the mobile broadband hedonic analysis, we calculate the overall national population density by using the OECD's population and land area datasets.[168] We divide the most recently available national population (2020) by the most recently available land area (2019) to obtain 2020 overall population density.[169]

115. *Fixed Coverage.* For the fixed broadband hedonic analysis, we include a variable measuring the percentage of households with access to broadband with download speeds of greater than 100 Mbps in each country. For the 21 European comparison countries, we use data presented in the Broadband Coverage in Europe 2021 Report on the percentage of households in areas where broadband with a download speed of greater than 100 Mbps was deployed as of June 2021.[170] For the United States, we rely on FCC Form 477 data for the same measure, as of June 2021.[171] For Canada, we use the percentage of households with fixed broadband service of at least 100 Mbps available as of 2019.[172]

116. For the remaining three countries, we relied on proxy measures of coverage. For Australia, the Australian government reports that 66% of premises were able to access fixed broadband services with download speeds greater than or equal to 100 Mbps as of September 2020.[173] For Mexico, we use data from Instituto Federal de Telecomunicaciones - Banco de Informacion de Telecomunicaciones, which reports the percentage of access by technology as of June 15, 2021; we assume that Fiber and Cable Coaxial are the only technologies that could achieve a download speed of 100 Mbps and that DSL, Satellite, Fixed Wireless, and Other Technologies are below this threshold.[174]

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[166] OECD, *National population distribution*, https://data.oecd.org/popregion/national-population-distribution.htm#indicator-chart (last visited Oct. 6, 2022).

[167] OECD, *National area distribution*, https://data.oecd.org/popregion/national-area-distribution.htm#indicator-chart (last visited Oct. 6, 2022).

[168] OECD, *OECD.Stat*, https://stats.oecd.org/ (last visited Oct. 6, 2022).

[169] Land area rarely changes from year to year in the dataset, and when it does, the changes are minimal. Therefore, we believe it is reasonable to use 2019 land area with 2020 population data.

[170] *See generally* Broadband Coverage in Europe 2021 Report; *see also supra* Fig. 1.

[171] FCC Form 477 Data as of June 30, 2021; *see also infra* Fig. 59.

[172] Canadian Radio-television and Telecommunications Commission, Communications Monitoring Report 2020 at 105 (2020), https://crtc.gc.ca/pubs/cmr2020-en.pdf (navigate to Fig. 4.7 Broadband service availability by speed (% of households)).

[173] Australian Government, Department of Infrastructure, Transport, Regional Development and Communications & Bureau of Communications, Arts and Regional Research, Measuring Australia's fixed broadband performance - compendium at 7 (2020), https://www.infrastructure.gov.au/sites/default/files/documents/measuring-australias-fixed-broadband-performance-compendium.pdf.

[174] Instituto Federal de Telecomunicaciones, *Indicadores por Pais*, https://bit.ift.org.mx/SASVisualAnalyticsViewer/VisualAnalyticsViewer_guest.jsp?reportSBIP=SBIP%3A%2F%2F

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For New Zealand, we rely on data from the country's Ministry of Business, Innovation, and Employment related to their Ultra-Fast Broadband (UFB) initiative.[175] In particular, we use the percentage of the population in New Zealand with access to at least 100 Mbps download and 50 Mbps upload speeds for the second quarter of 2021.[176]

117. *Mobile Network Quality Variable.* To construct the mobile network quality measure used in our hedonic regressions, we perform a principal components analysis of the four network quality proxy variables (download speed, upload speed, 4G availability, and 5G Availability), using the provider-level data from Opensignal. We keep only the first principal component from this analysis, which explains about 56% of the variation in the four network quality measures.[177] We then standardize the first principal component so that the mean value is zero and the standard deviation is one across the 84 provider-level values. This standardized first principal component is then used as a proxy measure for network quality in both the fixed broadband and mobile broadband hedonic analyses.

118. *Mobile Download and Upload Speeds.* For the mobile broadband hedonic analysis, we use most recently available provider-level overall download speeds based on Opensignal reports.[178] Because Opensignal does not report data for Iceland or Luxembourg, we impute values for the providers in these countries by running a simple regression of Opensignal's overall download speed at a country-level (weighting provider-level download speeds by market share) on Ookla's[179] 2021 country-level overall download speeds and predicting country-level download speeds for Iceland and Luxembourg.[180] We perform the same analysis to predict upload speeds for Iceland and Luxembourg.

119. *Mobile 4G Availability and 5G Availability.* For the mobile broadband hedonic analysis, we use OpenSignal's provider-level measure of 4G Availability which is defined as "the proportion of time Opensignal users with a 4G device and a 4G subscription – but have never connected to 5G - had a 4G connection."[181] 5G Availability is similarly defined as "the proportion of time Opensignal users with a 5G device and a 5G subscription - had an active 5G connection."[182] For each country, we use the most

(Continued from previous page)
METASERVER%2FShared%20Data%2FSAS%20Visual%20Analytics%2FReportes%2FIndicadores%20Internacionales(Report)&page=vi124825&sso_guest=true&informationEnabled=false&commentsEnabled=false&alertsEnabled=false&reportViewOnly=true&reportContextBar=false&shareEnabled=false (last visited Oct. 6, 2022). The data can be accessed by clicking on the "Datos por Pais" header, then clicking on the "Servicio Fijo de Internet" header.

[175] Crown Infrastructure Partners, Quarterly Connectivity Update Q2: to 30 June 2021 at 5 (2021), https://www.mbie.govt.nz/dmsdocument/16538-quarterly-connectivity-update-q2-to-30-june-2021.

[176] UFB NZ, *Glossary*, https://ufb.org.nz/terms/ (last visited Oct. 6, 2022).

[177] Principal components analysis is a standard method used in statistics for reducing a large set of variables into a smaller set of variables that retain most of the information contained in the larger variable set.

[178] Opensignal, *Market Insights*, https://www.opensignal.com/market-insights (last visited Oct. 6, 2022).

[179] Ookla SPEEDTEST intelligence data, © 2022 Ookla, LLC. All rights reserved. Published with permission of Ookla.

[180] The imputed download and upload speeds for Iceland and Luxembourg are constant across providers for these countries because we do not have a reasonable way to predict provider-level download and upload speeds for the providers in these countries. The country-level Ookla download speed data are the same data used in section III, but the overall country-level download speeds and upload speeds include all technologies. Also, in the simple regression for imputing country-level download and upload speeds for Iceland and Luxembourg, we use the other 34 comparison countries presented in that analysis.

[181] Opensignal, *Understanding mobile network experience: what do Opensignal's metrics mean?* (Mar. 24, 2022), https://www.opensignal.com/2022/03/24/understanding-mobile-network-experience-what-do-opensignals-metrics-mean.

[182] *Id*.

recent Market Insight report(s) available,[183] except for Iceland and Luxembourg for which Opensignal does not report data. We impute country-level 4G Availability and 5G Availability values for these two countries by, again, relying upon country-level Ookla Speedtest data.[184] Specifically, we calculate the 2021 percentage of all speed tests on 4G LTE technology. Then, we calculate the country-level 4G availability by weighting the provider-level values by market share and regressing Opensignal 4G availability on the percentage of tests on 4G LTE networks to predict values for Iceland and Luxembourg. We follow the same approach to impute the 5G availability values for Iceland and Luxembourg.[185]

120. *Fixed Data Usage.* For the fixed broadband calculation of average monthly data usage, we rely on three different sources: (1) the TeleGeography GlobalComms Database, (2) the 2022 ITU Database, and (3) Ofcom.[186] The TeleGeography GlobalComms Database's Fixed Data Traffic Volume dataset has a monthly average representing a period of several months in either 2021 or 2022.[187] We divide monthly averages from the TeleGeography dataset by the total number of fixed broadband subscribers from OECD data to obtain the monthly fixed broadband data usage per subscriber.[188] The 2022 ITU Database reports the total annual data usage (in exabytes) by country.[189] We rely on Ofcom data for fixed broadband data consumption per capita.[190] We multiply these values by OECD population totals and then divide them by the total number of fixed broadband subscribers from OECD in order to get the monthly fixed broadband data usage per subscriber.

121. *Mobile Data Usage.* For the mobile broadband analysis, we use average monthly data usage reported by the OECD as of 2020.[191]

122. *Terrain Roughness (Weighted by Population).* Our measure of terrain roughness is a population weighted terrain ruggedness index.[192] The index is constructed by calculating the terrain ruggedness index for each 30 by 30 arc-second cell using elevation data across the surface of the Earth. Let $e_{r,c}$ denote the elevation at the point located in row r and column c of a grid of elevation points. The

[183] Opensignal, *Market Insights*, https://www.opensignal.com/market-insights (last visited Oct. 6, 2022).

[184] The imputed 4G Availability and 5G Availability values for Iceland and Luxembourg are constant across providers in these countries because we do not have a reasonable way to predict provider-level values for the providers in these countries. Also, in the simple regressions for imputing country-level 4G Availability and 5G Availability values for Iceland and Luxembourg, we use the other 34 comparison countries presented in section III.

[185] All three of the providers in Luxembourg advertise 5G plans, and one of the three providers in Iceland advertises 5G plans.

[186] For a given country, if we have values from multiple sources, we take the average of these values.

[187] TeleGeography, *TeleGeography GlobalComms Database*, http://www.telegeography.com (last accessed Oct. 6, 2022) (navigate to *Data Traffic* within the *GlobalComms Database*). Fixed data traffic covers the number of bytes of data traffic originating on fixed broadband networks (xDSL, Cable, FTTx, WiMAX, etc.) within a given country. These volumes include download and upload traffic wherever possible.

[188] OECD, *Broadband Portal*, https://www.oecd.org/sti/broadband/broadband-statistics/ (last visited Oct. 6, 2022).

[189] International Telecommunication Union, *World Telecommunications/ICT Indicators Database 2022 (26th Edition/July 2022)* (last accessed Sept. 16, 2022). We do not provide URLs for ITU data throughout this section because it is a paid subscription service that cannot be publicly accessed.

[190] Ofcom, *International Broadband Scorecard 2021: Interactive Data*, https://www.ofcom.org.uk/research-and-data/telecoms-research/broadband-research/eu-bbroadand-scorecard/international-broadband-scorecard-2021-interactive-data (last visited Oct. 6, 2022).

[191] OECD, *Broadband Portal*, https://www.oecd.org/sti/broadband/broadband-statistics/ (last visited Oct. 6, 2022).

[192] Nathan Nunn & Diego Puga, *Ruggedness: The Blessing of Bad Geography in Africa*, 94 The Review of Economics and Statistics 20 (2012).

terrain roughness index (TRI) calculates the sum squared elevation change of the cell relative to adjacent cells:

$$TRI_{r,c} = \sum_{i=r-1}^{r+1} \sum_{j=c-1}^{c+1} \left(e_{i,j} - e_{r,c}\right)^2$$

123. These values are then weighted by the share of the country population in each cell to calculate the weighted average terrain ruggedness index for the country. The values calculated are reported in 100s of meters.[193]

124. *Content Quality Variable.* In Figure 61, we report various proxy measures for content quality as well as each country's primary language. The number of websites in top-level domains (TLDs) shows the count of all domains in each country's main TLD (e.g., Germany uses .de) according to DomainTools.com. For the United States, we aggregate over several major domains: .com, .net, .org, and .us. Similarly, we use the same TLDs to report the number of web pages in the TLDs by searching Google's search engine ("site:.de") and recording the number of search results. We divide the number of domains and the number of webpages by the country's population to get per capita measures. Also, we report each country's English Proficiency Index (EPI) score as a measure of access to English language content.[194] Another proxy measure is the percentage of the top 10 million websites in each country's primary language.[195] From these data, we find that English-based websites represent over 60% of the top 10 million websites. Although these statistics are not perfect measurements of content quality, they demonstrate that English language content is the dominant form of content available to broadband subscribers.

125. To construct the content quality measure used in our hedonic regressions, we perform a principal component analysis of the four content quality proxy variables (webpages by TLD per capita, domains by TLD per capita, EPI, and content language percentage), using the 26 country-level observations. We keep only the first principal component from this analysis, which explains about 52% of the variation in the four content quality measures. We then standardize the first principal component so that the mean value is zero and the standard deviation is one across the 26 country-level values. This standardized first principal component is then used as a proxy measure for content quality in both the fixed broadband and mobile broadband hedonic analyses.

126. *Domains by Top-Level Domains Per Capita.* First, we determine the TLD(s) for each country, and then aggregate the counts of all domains in each TLD over the country's TLD(s).[196] Next, we divide the total domains by the country's population to get the domains per capita.[197] Figure 61 reports the TLD(s) assigned to each country.

127. *Webpages by Top-Level Domains Per Capita.* Using the same TLDs for each country, we determine the number of webpages using Google's search engine for each TLD (for example,

[193] Nathan Nunn & Diego Puga, *Data and replication files for 'Ruggedness: The blessing of bad geography in Africa'*, https://diegopuga.org/data/rugged/ (last visited Oct. 6, 2022).

[194] Education First, *The world's largest ranking of countries and regions by English skills*, https://www.ef.com/wwen/epi/ (last visited Oct. 6, 2022).

[195] W^{3}Techs, *Usage statistics of content languages for websites*, https://w3techs.com/technologies/overview/content_language (last visited Oct. 6, 2022).

[196] DomainTools, *Domain Count Statistics for TLDs*, https://research.domaintools.com/statistics/tld-counts/ (last visited Oct. 6, 2022).

[197] OECD, *OECD.Stat*, https://stats.oecd.org/ (last visited Oct. 6, 2022). The most recently available country population data are dated 2020.

"site:.com"). Then, we aggregate over TLDs for each country and divide the total webpages for each country by the country's population to get the webpages per capita.

128. *English Proficiency Index*. We use a measure of a country's English proficiency from Education First, called the EPI.[198] In the most recent EPI report, Education First reports an EPI score for each country except Australia, Canada, Iceland, Ireland, New Zealand, the United Kingdom, and the United States. With the exception of Iceland, we assume that these countries are all native English-speaking countries and set the EPI score to 100% for our analyses. For Iceland, we assume a "Very High Proficiency" and set the EPI score to the average EPI score of other sampled countries in this category.[199]

129. *Content Language.* For both the fixed broadband and mobile broadband hedonic analyses, we use the percentage of websites with different content languages.[200] A content language is defined as the natural language of the text on a website. The primary language spoken in each country is shown in Figure 61.

d. Price Index Construction

130. We use the same general methodology to calculate the fixed broadband and mobile broadband price indexes in Figure 41 and Figure 44, respectively. The supplementary figures of broadband prices by product referenced here are available in section IV.G below.

131. *Step 1.* We calculate the unweighted average price of all plans for each provider within each product category.[201] Therefore, each provider has up to six product prices.

132. *Step 2.* Next, we calculate a weighted average price of each product category across providers, using provider market shares as the weight. If a provider does not offer any plans in a particular product category, it carries zero weight; and, the weights of remaining providers are proportional to only those providers that do offer a product in the given product category.[202] Figure 51 and Figure 56 display the country-level product prices for fixed broadband and mobile broadband, respectively.

133. *Step 3.* There are cases in which no provider in a country offers plans in a product category, thus we make assumptions about missing country-level product prices. First, if a bundled product price is missing, we replace it with the corresponding standalone product price (i.e., setting the bundle discount to zero).[203] Next, if the highest tiered product(s) is not offered, we set the missing product price(s) to the next available product price. For example, if no providers in the country offer product 1, then we set its value equal to the price of product 2. If both products 1 and 2 are not offered, then we set both product values to the price of product 3. Finally, for any remaining missing product

[198] Education First, EF English Proficiency Index at 6-7 (2021), https://www.ef.com/assetscdn/WIBIwq6RdJvcD9bc8RMd/cefcom-epi-site/reports/2021/ef-epi-2021-english.pdf.

[199] In Iceland, English is the "first" foreign language in the Icelandic National Curriculum for compulsory schools. *See* Iceland Ministry of Education, Science and Culture, The Icelandic National Curriculum Guide for Compulsory Schools – with Subjects Areas at 50 (2014), https://www.government.is/library/01-Ministries/Ministry-of-Education/Curriculum/adalnrsk_greinask_ens_2014.pdf.

[200] W3Techs, *Usage statistics of content languages for websites*, https://w3techs.com/technologies/overview/content_language (last visited Oct. 6, 2022).

[201] This calculation includes "synthetic plans."

[202] If only one provider in a country offers plans in a product category, that provider's unweighted average price would represent 100% of the country-level product price.

[203] Specifically, we set the price of product 4 to the price of product 1; the price of product 5 to the price of product 2; and the price of product 6 to the price of product 3.

prices, we set these to the next highest available product price.[204] For example, if providers in a country only offer products 1 and 3, then the price of product 2 is set to the price of product 3.

134. *Step 4.* Finally, we calculate the price indexes using the full set of country-level product prices from Step 3, and the product shares in Figure 39 for fixed broadband and Figure 40 for mobile broadband.[205] For fixed broadband, we calculate the overall standalone price and overall bundled price by using the download speed shares in Figure 41. For mobile broadband, we calculate the overall single-line price and overall multi-line price by using the data usage shares in Figure 44. To calculate the overall broadband price, we use the bundle shares to weight the overall standalone price and overall bundle price.

135. *Step 5.* To produce price per GB rankings, we divide the overall broadband price calculated in Step 4 by the average monthly data usage in each country.[206]

2. Hedonic Regression Model

136. The classic hedonic framework involves adjusting for changing product quality over time, and accounting for product quality differences across firms and countries is analogous. In the equation below, we present a standard linear hedonic regression of prices on product characteristics.[207]

$$\ln(P_{ik}) = \alpha_k + X_i\beta + \varepsilon_{ik}$$

137. The dependent variable, $\ln(P_{ik})$, is the logarithm of the price of plan *i* in country *k*, X_i is a vector of plan characteristics, and ε_{ik} is a scalar idiosyncratic error term. Under this approach, the country specific intercepts, α_k, estimate the differences in the average quality-adjusted price levels across countries. This framework has been widely used in making temporal and spatial price comparisons; however, it is not ideal for cross-country broadband pricing comparisons because it assumes that coefficients on product characteristics (the slope parameters β) are the same for each country.[208] While it is plausible that the supply and demand conditions that generate the β coefficients could be similar in adjacent time periods, or even cities within the same country, it is highly unlikely that these conditions are similar across countries. If broadband cost structures, determinants of demand (e.g., demographics), product offerings, ownership structures, regulatory conditions, subsidies, or other conditions that impact prices vary across countries, then we would expect the slope parameters to reflect these differences.

138. We estimate a more flexible model that allows the slope coefficients for certain characteristics to differ across providers. However, due to sample size limitations in our pricing data, we

[204] This assures that U.S. consumers are at least as well-off with the product provided as they would have been with the product available in the United States.

[205] *See supra* para. 66 (price index formula). *See also* TeleGeography, *TeleGeography GlobalComms Database*, http://www.telegeography.com (last accessed Oct. 6, 2022); International Telecommunication Union, *World Telecommunications/ICT Indicators Database 2020 (24th Edition/July 2020)* (last accessed Aug. 31, 2022).

[206] For fixed broadband, we only have monthly average usage per subscriber data for 18 of the 26 countries. TeleGeography, *TeleGeography GlobalComms Database*, http://www.telegeography.com (last accessed Oct. 6, 2022) (navigate to *Data Traffic* within the *GlobalComms Database*); Ofcom, *International Broadband Scorecard 2021: Interactive Data*, https://www.ofcom.org.uk/research-and-data/telecoms-research/broadband-research/eu-bbroadand-scorecard/international-broadband-scorecard-2021-interactive-data (last visited Oct. 6, 2022). For mobile broadband, we rely on OECD monthly average usage per subscriber data. *See* OECD, *Broadband Portal*, https://www.oecd.org/sti/broadband/broadband-statistics/ (last visited Oct. 6, 2022).

[207] *See* Zvi Griliches, *Hedonic Price Indexes for Automobiles: An Econometric Analysis of Quality Change*, The Price Statistics of the Federal Government 173 (1st ed. 1961).

[208] *See* W. Erwin Diewert, Saeed Heravi, & Mick Silver, *Hedonic Imputation versus Time Dummy Hedonic Indexes*, Price Index Concepts and Measurement 161 (1st ed. 2009).

do not estimate all of the *j* possible slope parameters for each product characteristic at the provider-level but rather use multilevel modeling techniques similar to those recently proposed in broadband price hedonic work at the OECD.[209] The multilevel model recognizes that plans are nested within providers which are nested within countries, and that prices are likely correlated within these nests. Rather than estimating separate parameters for each provider and product characteristic, the model assumes normally distributed zero-mean random coefficients on some product characteristics at the provider-level and then estimates the variance of each random coefficient. The model is therefore more parsimonious because it estimates a single unknown variance parameter for each product characteristic rather than a separate slope parameter for each provider by product characteristic combination.

139. To explain why prices may differ across countries, we also include some exogenous supply and demand shifters into the model that we expect to explain why broadband quality-adjusted price levels may differ by country. In the standard model, these factors are absorbed in the country fixed effect, so instead of including this fixed effect, we parametrize the more traditional country effect as a random effect plus country-level supply and demand factors that we expect to be correlated with average price levels. This allows us to remove the effect of these country-level supply and demand conditions when predicting prices rather than including them in the price predictions as they would in a fixed effect specification.

140. Our base multilevel hedonic pricing equation is as follows:

$$\ln(P_{ijk}) = X_i\beta + Z_k\gamma + \tilde{X}_i\tilde{\beta}_j + \mu_j + \nu_k + \varepsilon_{ijk}, \text{ where}$$

- P_{ijk} is the price for plan *i*, offered by provider *j*, in country *k*;
- X_i is a vector of plan characteristic variables;[210]
- β is a vector of unknown fixed coefficients;
- Z_k is a vector of country characteristics (e.g., measures of income and population density) for the country in which the given plan is offered;
- γ is a vector of unknown, fixed coefficients for the country characteristics;
- $\tilde{X}_i$ is a subset of the variables in X_i for which the coefficients will be treated as random realizations for each provider in each country;
- $\tilde{\beta}_j$ is a vector of random coefficients for the variables included in $\tilde{X}_i$. These random coefficients apply to all plans of provider *j*. We assume that $E[\tilde{\beta}] = 0, Cov[\tilde{\beta}, \varepsilon] = 0, and\ Var[\tilde{\beta}] = G$;[211]

[209] *See* Carol Corrado & Olga Ukhaneva, *Hedonic Prices for Fixed Broadband Services: Estimation across OECD Countries*, (Oct. 20, 2016), https://www.oecd-ilibrary.org/docserver/5jlpl4sgc9hj-en.pdf?expires=1603997556&id=id&accname=guest&checksum=1D0A776B692D8F368F8A696A24A0E702. These models are also called "random effects models," "hierarchical linear models," and "mixed models."

[210] The plan characteristics included in X_i for fixed broadband are three splines of download speed, a dummy variable for whether the plan is bundled with video service, a dummy variable for whether fixed voice is included, a dummy variable for whether more than 2000 GB of data is included (i.e., unlimited data), and a dummy variable for whether download and upload speeds are symmetric. For mobile broadband, they include the number of lines, a family plan dummy indicating whether more than one line is included, the logarithm of the data cap per line, an unlimited data dummy, an unlimited minutes dummy, an unlimited text messages dummy, the logarithm of the maximum download speed, and a dummy if the plan allows access to a provider's 5G network. Since the inclusion of too many variables can result in the statistical problem of "overfitting" the data, we did not include all observed product characteristics in the model and limited the random coefficients to only those we determined were key product characteristics that likely had the greatest impact on consumer choices.

- μ_j is a random coefficient applying to all plans offered by provider *j*;
- ν_k is a random coefficient applying to all plans offered in country *k*; and
- ε_{ijk} is an idiosyncratic error term.

141. The multilevel model is estimated by maximum likelihood estimation (MLE). In matrix form, the model can be written as:[212]

$$\ln(p) = X\beta + \tilde{X}\tilde{\beta} + Z\gamma + \varepsilon.$$

142. The n × 1 vector of errors ε is assumed to be normally distributed mean-zero multivariate with variance-covariance matrix $\sigma_\varepsilon^2 I_n$. We also assume that $\tilde{\beta}$ is mean zero, orthogonal to ε, and has variance-covariance matrix G. This implies the following:

$$\text{Var}\begin{bmatrix}\tilde{\beta}\\ \varepsilon\end{bmatrix} = \begin{bmatrix}G & 0\\ 0 & \sigma_\varepsilon^2 I_n\end{bmatrix}.$$

143. Letting $u = \tilde{X}\tilde{\beta} + \varepsilon$ be the combined error term, we see that ln(*p*) is normally distributed multivariate with mean $X\beta + Z\gamma$ and the following variance-covariance matrix:

$$V = \tilde{X}G\tilde{X}' + \sigma_\varepsilon^2 I_n.$$

144. Letting θ be a vector of the unknown variance components of G, we have the following likelihood function that is used to find the unique vectors β, θ, and σ_ε^2 that maximize this likelihood of observing our data sample.[213]

$$L(\beta, \theta, \sigma_\varepsilon^2) = \left\{-\frac{1}{2}\text{n}\ln(2\pi) + \ln|V| + (\ln(p) - X\beta - Z\gamma)'V^{-1}(\ln(p) - X\beta - Z\gamma)\right\}.$$

145. Following estimation of the model, we predict broadband prices for each provider for a set of standardized plans. Since the random effects $\tilde{\beta}$ are not directly estimated, we calculate them post-estimation by using the following best linear unbiased estimator of the random effects, where variables with ^ denote estimated objects from the MLE:

$$\hat{b} = \hat{G}'\tilde{X}'\hat{V}^{-1}\left(\ln(p) - X\hat{\beta} - Z\hat{\gamma}\right).$$

146. The predicted price for any one of the six standardized plans used to compare prices across countries is then given by the following formula:

$$\ln\left(P_{ijk}\right) = X_i\hat{\beta} + Z_k\hat{\gamma} + \tilde{X}_i\hat{b}_j + \hat{\mu}_j + \hat{v}_k.$$

147. The random coefficients on product characteristics measure how each provider's pricing of the characteristic differs from the pricing of the average provider in the sample as measured by the

(Continued from previous page)

[211] The model does not estimate the random coefficients $\tilde{\beta}$, μ_j, or ν_k, but instead estimates the diagonal variance elements of the variance-covariance matrix G, known as the variance components. The off-diagonal covariances are assumed to be zero. When predicting prices for each provider, we use the best linear unbiased predictors of the random coefficients based on the estimated variance components.

[212] In the matrix representation, the provider and country random effects are now included in the vector of random coefficients $\tilde{\beta}$.

[213] We use the Stata mixed command to estimate the model. For further details on the maximum likelihood estimation routine, *see* StataCorp LP, STATA Multilevel Mixed-Effects Reference Manual Release 13, https://www.stata.com/manuals13/me.pdf (last visited Oct. 6, 2022).

coefficient β.[214] In our fixed broadband hedonic models, the product characteristics with provider random coefficients are three download speed splines and a dummy for symmetric download and upload speeds.[215] In our mobile broadband hedonic models, there are country random coefficients on a family plan dummy, a logarithm of data cap per line, an unlimited data cap dummy, and the logarithm of maximum download speed.[216]

148. In an imperfectly competitive market such as broadband, there is no meaningful interpretation of the hedonic regression coefficients. Under perfect competition, the coefficient vector β estimates both the marginal consumer value and marginal production costs for each product characteristic.[217] However, in markets like broadband with substantial fixed costs, the coefficient also includes the markup over cost for that characteristic, and these markups are complex functions of the characteristics of competing products, firm costs, consumer preferences, and market structure.[218] As such, in imperfectly competitive markets, hedonic coefficients should only be considered as a reduced-form description of how prices (costs plus markups) vary with changes in product characteristics. The focus should not be on the particular value, sign, or precision of any one coefficient but rather on how predictive the hedonic pricing function is of provider prices in each country.[219] We therefore follow a standard hedonic approach, except we correct price levels for exogenous country-level factors that we expect to be correlated with costs and markups by predicting prices for all countries at the U.S. values of Z_k.

G. Supplementary Figures

149. Following are our supplementary figures that provide additional data and information.

[214] *See infra* Fig. 52, Fig. 57 (fixed and mobile broadband, respectively, estimated variances of the random coefficients).

[215] We control for download speeds using a linear spline in the logarithm of download speed with knot points at the top-end of our speed categories used to define the six broadband products (i.e., knots at 100 and 250 Mbps).

[216] We control for data allowances using a linear spline in the logarithm of the data allowance with knot points at the top-end of our data allowance categories used to define mobile broadband products with the three highest data allowances (i.e., knots at 10 and 25 GB).

[217] *See* Sherwin Rosen, *Hedonic Prices and Implicit Markets: Product Differentiation in Pure Competition*, 82 Journal of Political Economy 34 (1974).

[218] *See generally* Pakes; Robert C. Feenstra & Gordon H. Hanson, Foreign Investment, Outsourcing and Relative Wages (1995), https://www.nber.org/system/files/working_papers/w5121/w5121.pdf; Diane Bruce Anstine, *How Much Will Consumers Pay? A Hedonic Analysis of the Cable Television Industry*, 19 Review of Industrial Organization 129 (2001). Even if the broadband market is competitive in a country, pricing will still need to be above marginal cost for firms to recover their fixed deployment costs.

[219] *See generally* Pakes (2003).

Fig. 48. Fixed Broadband and Mobile Broadband Combined Hedonic Price Indexes

Country	Model 1		Model 2		Model 3		Model 4	
	Price	Rank	Price	Rank	Price	Rank	Price	Rank
Australia	112.44	22	113.88	12	112.58	9	142.40	9
Austria	98.50	18	211.88	25	249.92	25	306.12	25
Belgium	103.91	21	143.09	19	143.10	20	202.13	23
Canada	156.91	25	162.01	24	153.93	23	184.26	20
Czech Republic	70.01	7	151.79	21	130.44	18	154.61	12
Denmark	69.81	6	92.77	3	84.91	2	115.61	2
Estonia	81.78	12	123.65	16	123.97	15	168.76	17
Finland	83.30	13	96.32	4	93.91	3	138.95	7
France	59.63	4	113.50	11	124.06	17	169.95	19
Germany	72.74	9	124.10	17	123.25	14	165.54	16
Greece	83.65	14	155.78	23	161.58	24	208.67	24
Iceland	99.28	19	99.51	5	98.71	4	131.10	5
Ireland	70.57	8	91.86	2	106.96	6	134.62	6
Italy	45.52	2	110.08	10	124.05	16	155.25	13
Latvia	45.44	1	73.89	1	75.39	1	110.13	1
Luxembourg	101.15	20	109.64	9	114.04	10	155.35	14
Mexico	92.99	16	276.43	26	301.99	26	355.20	26
Netherlands	77.91	10	117.09	14	101.40	5	139.54	8
New Zealand	97.07	17	101.57	6	108.86	8	130.46	4
Norway	170.08	26	152.71	22	144.13	21	197.33	22
Portugal	66.70	5	132.76	18	135.65	19	169.43	18
Spain	56.36	3	106.09	7	119.76	11	155.59	15
Sweden	91.00	15	107.52	8	107.20	7	154.37	11
Switzerland	136.87	24	150.19	20	152.37	22	186.30	21
United Kingdom	78.16	11	114.65	13	121.70	13	143.24	10
United States	**121.76**	**23**	**121.16**	**15**	**121.02**	**12**	**121.59**	**3**

Fig. 49. Fixed Broadband Average Bundle Discounts and Discount Rates (PPP Adjusted)

Country	Discount	Discount Rate
Australia		
Austria		
Belgium	49.79	37.2%
Canada		
Czech Republic	16.62	17.1%
Denmark		
Estonia	10.98	15.4%
Finland	3.96	4.6%
France		
Germany	13.84	17.9%
Greece	5.82	7.0%
Iceland		
Ireland	3.17	2.9%
Italy		
Latvia	7.23	10.7%
Luxembourg		
Mexico		
Netherlands	23.51	26.1%
New Zealand		
Norway	18.54	12.6%
Portugal		
Spain		
Sweden	7.13	6.9%
Switzerland		
United Kingdom	12.24	14.4%
United States	**26.80**	**11.3%**

Note: Prices are reported in PPP adjusted U.S. dollars.

Fig. 50. Fixed Broadband Unweighted Average Prices by Product (PPP Adjusted)

Country	Standalone						Bundled					
	0 < Mbps < 100		100 ≤ Mbps < 250		Mbps ≥ 250		0 < Mbps < 100		100 ≤ Mbps < 250		Mbps ≥ 250	
	Mean	Count	Mean	Count	Mean	Count	Mean	Count	Mean	Count	Mean	Count
Australia	50.18	9	73.07	3			50.18	9	73.07	3		
Austria	39.80	3	48.63	3	67.61	6	39.80	3	48.63	3	67.61	6
Belgium	40.39	2	60.57	4	81.22	4	40.39	2	52.59	4	74.51	4
Canada	64.13	20	78.27	7	101.44	20	64.13	20	78.27	7	101.44	20
Czech Republic	41.18	7	49.92	3	50.80	7	35.59	13	45.63	5	49.76	9
Denmark	41.62	8	40.04	3	52.06	6	41.62	8	40.04	3	52.06	6
Estonia	41.82	10	54.06	4	102.13	7	41.14	10	52.25	4	102.13	7
Finland	48.76	2	45.30	2	65.51	3	48.76	2	43.94	2	62.67	3
France	35.86	3			48.58	9	35.86	3			48.58	9
Germany	40.81	7	44.70	4	50.78	6	39.31	7	43.58	4	48.25	6
Greece	46.87	8	63.64	7			46.07	12	59.66	15		
Iceland					73.46	8					73.46	8
Ireland			58.40	2	67.85	9			58.40	2	67.42	9
Italy			38.68	5	48.93	7			38.68	5	48.93	7
Latvia			33.57	2	45.59	3			30.97	4	36.58	8
Luxembourg	51.04	1	63.52	2	84.96	5	51.04	1	63.52	2	84.96	5
Mexico	34.38	2	52.40	11	112.75	8	34.38	2	52.40	11	112.75	8
Netherlands	49.67	3	56.97	4	66.01	4	42.12	4	56.97	4	52.68	7
New Zealand	57.65	5			61.58	8	57.65	5			61.58	8
Norway			95.42	7	119.78	17			92.76	7	112.99	17
Portugal	53.57	6	56.20	6	66.10	9	53.57	6	56.20	6	66.10	9
Spain			47.88	1	55.55	9			47.88	1	55.55	9
Sweden	35.27	11	42.67	16	70.00	47	35.27	11	42.65	17	69.06	51
Switzerland			50.32	2	62.77	4			50.32	2	62.77	4
United Kingdom	42.12	11	48.97	3	66.32	4	40.91	11	48.97	3	66.32	4
United States	**61.79**	**4**	**69.72**	**3**	**89.05**	**22**	**61.79**	**4**	**69.72**	**3**	**86.03**	**28**
Total		122		104		232		133		117		252

Note: Prices are reported in PPP adjusted U.S. dollars.

Fig. 51. Fixed Broadband Weighted Average Prices by Product (PPP Adjusted)

Country	Standalone						Bundled					
	0 < Mbps < 100		100 ≤ Mbps < 250		Mbps ≥ 250		0 < Mbps < 100		100 ≤ Mbps < 250		Mbps ≥ 250	
	Mean	Count	Mean	Count	Mean	Count	Mean	Count	Mean	Count	Mean	Count
Australia	55.88	9	73.21	3			55.88	9	73.21	3		
Austria	39.82	3	48.68	3	68.07	6	39.82	3	48.68	3	68.07	6
Belgium	38.32	2	56.48	4	77.23	4	38.32	2	52.64	4	74.00	4
Canada	60.32	20	78.95	7	98.01	20	60.32	20	78.95	7	98.01	20
Czech Republic	42.29	7	50.57	3	59.19	7	39.74	13	47.70	5	56.14	9
Denmark	41.05	8	40.10	3	48.20	6	41.05	8	40.10	3	48.20	6
Estonia	41.82	10	54.84	4	99.26	7	41.34	10	53.83	4	99.26	7
Finland	48.76	2	46.52	2	65.51	3	48.76	2	45.00	2	62.67	3
France	38.37	3			49.93	9	38.37	3			49.93	9
Germany	42.73	7	47.59	4	56.11	6	41.43	7	46.76	4	54.71	6
Greece	48.52	8	67.52	7			47.12	12	62.58	15		
Iceland					73.18	8					73.18	8
Ireland			59.17	2	66.20	9			59.17	2	65.90	9
Italy			38.82	5	49.18	7			38.82	5	49.18	7
Latvia			33.57	2	45.87	3			30.97	4	40.28	8
Luxembourg	51.04	1	63.77	2	82.01	5	51.04	1	63.77	2	82.01	5
Mexico	36.32	2	55.73	11	118.38	8	36.32	2	55.73	11	118.38	8
Netherlands	49.01	3	56.97	4	65.85	4	41.86	4	56.97	4	57.80	7
New Zealand	55.03	5			63.32	8	55.03	5			63.32	8
Norway			89.86	7	121.53	17			87.74	7	118.24	17
Portugal	51.51	6	56.36	6	65.41	9	51.51	6	56.36	6	65.41	9
Spain			47.88	1	55.88	9			47.88	1	55.88	9
Sweden	42.33	11	45.16	16	70.29	47	42.33	11	43.86	17	67.95	51
Switzerland			51.06	2	63.82	4			51.06	2	63.82	4
United Kingdom	45.03	11	48.24	3	64.08	4	43.94	11	48.24	3	64.08	4
United States	**57.83**	**4**	**79.74**	**3**	**87.40**	**22**	**57.83**	**4**	**79.74**	**3**	**86.14**	**28**
Total		122		104		232		133		117		252

Note: Prices are reported in PPP adjusted U.S. dollars.

Fig. 52. Fixed Broadband Estimated Variances of Random Coefficients and Likelihood Ratio Tests

Random Effect Parameters	Model 1		Model 2		Model 3	
	Estimate	SE	Estimate	SE	Estimate	SE
Country: Variance(Constant)	0.142	0.046	0.015	0.010	0.015	0.010
Provider: Variance(0 < Mbps < 100)	0.001	0.000	0.001	0.000	0.001	0.000
Provider: Variance(100 ≤ Mbps < 250)	0.068	0.015	0.070	0.015	0.070	0.015
Provider: Variance(250 ≤ Mbps)	0.030	0.007	0.030	0.007	0.030	0.007
Provider: Variance(Symmetric Speeds Dummy)	0.004	0.004	0.004	0.004	0.004	0.004
Provider: Variance(Constant)	0.032	0.009	0.031	0.009	0.031	0.009
Variance(Residual)	0.017	0.001	0.017	0.001	0.017	0.001
Likelihood Ratio Tests			**1 vs. 2**		**2 vs. 3**	
P-Value			0.000		0.794	

Fig. 53. Fixed Broadband Country Random Coefficients

Country	Model 1	Model 2	Model 3
Australia	0.333	0.048	0.041
Austria	-0.038	-0.004	-0.004
Belgium	0.037	0.000	0.004
Canada	0.454	0.202	0.204
Czech Republic	-0.419	-0.056	-0.051
Denmark	0.200	0.042	0.045
Estonia	-0.288	-0.099	-0.097
Finland	0.055	-0.072	-0.080
France	-0.253	-0.085	-0.092
Germany	-0.141	-0.064	-0.063
Greece	-0.377	-0.027	-0.037
Iceland	0.262	0.015	0.015
Ireland	0.109	0.020	0.019
Italy	-0.436	-0.096	-0.098
Latvia	-0.734	-0.136	-0.135
Luxembourg	0.221	-0.102	-0.100
Mexico	-0.614	0.133	0.134
Netherlands	0.034	0.055	0.059
New Zealand	0.451	0.073	0.075
Norway	0.742	0.098	0.100
Portugal	-0.119	0.125	0.131
Spain	-0.384	-0.088	-0.084
Sweden	0.157	-0.026	-0.026
Switzerland	0.284	-0.060	-0.058
United Kingdom	0.083	0.082	0.072
United States	**0.380**	**0.021**	**0.024**
Overall	0.000	0.000	0.000

Fig. 54. Mobile Broadband Average Discount Rates by Number of Lines Relative to Single-Line Plan (PPP Adjusted)

Country	2-Lines		3-Lines		4-Lines	
	Discount	Discount Rate	Discount	Discount Rate	Discount	Discount Rate
Australia	-0.03	-0.1%	-0.06	-0.1%	-0.08	-0.2%
Austria	-0.21	-0.3%	-0.27	-0.4%	-0.31	-0.4%
Belgium	-0.72	-1.9%	-0.72	-1.9%	-0.72	-1.9%
Canada						
Czech Republic						
Denmark	-1.65	-4.5%	-2.20	-6.0%	-2.48	-6.8%
Estonia	-0.51	-1.1%	-0.69	-1.5%	-0.77	-1.7%
Finland						
France						
Germany	-17.88	-27.0%	-20.20	-31.3%	-21.36	-33.4%
Greece						
Iceland	-0.39	-0.6%	-0.52	-0.8%	-0.58	-0.9%
Ireland						
Italy						
Latvia	-1.06	-2.0%	-1.06	-2.0%	-1.06	-2.0%
Luxembourg						
Mexico	-0.48	-1.0%	-0.54	-1.2%	-0.57	-1.2%
Netherlands	-0.20	-0.5%	-0.14	-0.3%	-0.20	-0.5%
New Zealand	-3.17	-6.5%	-4.23	-8.7%	-4.44	-9.0%
Norway	-2.59	-5.3%	-3.45	-7.0%	-3.88	-7.9%
Portugal	-6.58	-9.1%	-8.77	-12.1%	-9.86	-13.6%
Spain	-2.05	-5.9%	-2.74	-7.9%	-3.08	-8.9%
Sweden	-4.21	-9.0%	-5.65	-12.1%	-6.35	-13.6%
Switzerland						
United Kingdom	-0.07	-0.3%	-0.09	-0.4%	-0.11	-0.4%
United States	**-4.34**	**-6.3%**	**-9.89**	**-14.0%**	**-11.40**	**-15.7%**

Note: Plans that are not available as Single-Line Plans are not included. Prices are reported in PPP adjusted U.S. dollars.

Fig. 55. Mobile Broadband Unweighted Prices by Product (PPP Adjusted)

Country	Single Line Plans						Multi-Line Plans					
	0.2 < GB ≤ 10		10 < GB ≤ 25		25 < GB		0.2 < GB ≤ 10		10 < GB ≤ 25		25 < GB	
	Mean	Count	Mean	Count	Mean	Count	Mean	Count	Mean	Count	Mean	Count
Australia			31.27	1	45.44	13	23.63	1	28.32	7	42.18	51
Austria	22.70	1	40.43	21	59.15	17	22.70	3	39.44	66	56.94	54
Belgium	24.48	4	41.23	4	54.41	3	24.48	12	39.72	12	52.39	9
Canada			76.65	3	97.26	7	64.47	7	78.59	39	103.58	24
Czech Republic	49.49	6	65.98	3	82.25	8	49.49	18	65.98	9	82.25	24
Denmark			22.60	1	32.47	12	16.71	2	20.50	6	26.71	43
Estonia	23.78	5	35.21	4	62.92	5	23.78	15	35.21	12	59.42	15
Finland					40.22	12					40.22	36
France	20.61	3			43.39	17	20.61	9			43.39	51
Germany	39.36	5	62.33	4	66.51	8	28.00	19	33.08	20	51.86	24
Greece	67.04	4	96.80	1	83.60	3	54.99	28	83.15	5	87.50	11
Iceland	14.85	6	24.26	3	43.65	7	15.56	22	22.94	22	36.73	28
Ireland					37.56	5					36.81	21
Italy	20.62	1	25.01	1	31.40	12	20.62	3	25.01	3	31.40	36
Latvia	32.86	7	39.48	1	50.41	4	32.86	21	39.48	3	46.01	12
Luxembourg	13.58	4	39.64	2	61.45	3	13.58	12	39.64	6	61.45	9
Mexico	33.17	7	64.24	6	117.87	6	33.17	21	62.51	18	117.87	18
Netherlands	23.81	8	32.99	4	45.67	4	23.81	24	32.60	13	42.30	13
New Zealand	24.67	3	40.36	3	59.20	5	24.67	9	32.99	9	44.00	19
Norway	26.77	10	40.50	7	59.70	7	26.24	30	37.20	21	49.79	21
Portugal					73.74	6					64.65	18
Spain	17.51	3	22.26	1	50.27	9	16.49	9	22.26	3	41.05	30
Sweden	26.39	5	38.61	5	55.56	9	24.43	37	30.76	23	39.14	29
Switzerland	35.44	3			71.45	7	35.44	9			71.45	21
United Kingdom	19.81	11	23.98	4	33.26	20	21.72	45	26.65	16	33.13	72
United States	**64.48**	**3**			**81.17**	**9**	**42.35**	**17**			**57.28**	**30**
Total		99		79		218		373		313		719

Note: Prices are reported in PPP adjusted U.S. dollars.

Fig. 56. Mobile Broadband Weighted Prices by Product (PPP Adjusted)

Country	Single Line Plans						Multi-Line Plans					
	0.2 < GB ≤ 10		10 < GB ≤ 25		25 < GB		0.2 < GB ≤ 10		10 < GB ≤ 25		25 < GB	
	Mean	Count	Mean	Count	Mean	Count	Mean	Count	Mean	Count	Mean	Count
Australia			31.27	1	48.80	13	23.63	1	29.51	7	47.92	51
Austria	22.70	1	38.11	21	69.43	17	22.70	3	35.50	66	63.09	54
Belgium	26.88	4	42.51	4	53.64	3	26.88	12	40.79	12	51.16	9
Canada			76.65	3	95.36	7	64.68	7	78.54	39	98.56	24
Czech Republic	49.14	6	66.75	3	87.45	8	49.14	18	66.75	9	87.45	24
Denmark			22.60	1	32.82	12	16.71	2	21.32	6	26.67	43
Estonia	21.64	5	38.73	4	62.58	5	21.64	15	38.73	12	58.48	15
Finland					40.11	12					40.11	36
France	21.79	3			38.48	17	21.79	9			38.48	51
Germany	41.30	5	56.41	4	77.93	8	25.47	19	30.62	20	46.27	24
Greece	65.96	4	96.80	1	89.97	3	57.04	28	83.15	5	88.14	11
Iceland	14.81	6	24.13	3	43.52	7	15.43	22	23.16	22	37.32	28
Ireland					36.96	5					36.22	21
Italy	20.62	1	25.01	1	32.04	12	20.62	3	25.01	3	32.04	36
Latvia	32.99	7	39.48	1	49.71	4	32.99	21	39.48	3	43.08	12
Luxembourg	13.58	4	39.64	2	66.94	3	13.58	12	39.64	6	66.94	9
Mexico	33.35	7	64.32	6	117.47	6	33.35	21	62.27	18	117.47	18
Netherlands	24.49	8	34.33	4	46.00	4	24.49	24	33.90	13	44.49	13
New Zealand	24.14	3	40.36	3	58.93	5	24.14	9	33.69	9	41.66	19
Norway	30.32	10	44.93	7	60.26	7	29.34	30	40.62	21	50.18	21
Portugal					73.74	6					65.34	18
Spain	20.22	3	22.26	1	46.90	9	18.52	9	22.26	3	40.12	30
Sweden	26.37	5	40.14	5	57.23	9	24.51	37	30.72	23	38.12	29
Switzerland	40.20	3			78.26	7	40.20	9			78.26	21
United Kingdom	19.96	11	24.99	4	33.74	20	19.96	45	27.92	16	32.86	72
United States	**63.52**	**3**			**80.84**	**9**	**45.21**	**17**			**55.97**	**30**
Total		99		79		218		373		313		719

Note: Prices are reported in PPP adjusted U.S. dollars.

Fig. 57. Mobile Broadband Estimated Variances of Random Coefficients and Likelihood Ratio Tests

Random Effect Parameters	Model 1		Model 2		Model 3	
	Estimate	SE	Estimate	SE	Estimate	SE
Country: Variance(Family Plan Dummy)	0.014	0.005	0.014	0.005	0.013	0.005
Country: Variance(Log Data Cap)	0.013	0.004	0.014	0.004	0.014	0.004
Country: Variance(Unlimited Data Cap Dummy)	0.146	0.054	0.137	0.051	0.137	0.050
Country: Variance(Log Download Speed)	0.007	0.003	0.009	0.003	0.011	0.004
Country: Variance(Constant)	0.244	0.103	0.067	0.054	0.004	0.045
Provider: Variance(Constant)	0.099	0.020	0.097	0.020	0.096	0.020
Variance(Residual)	0.034	0.001	0.034	0.001	0.034	0.001
Likelihood Ratio Tests			**1 vs. 2**		**2 vs. 3**	
P-Value			0.021		0.020	

Fig. 58. Mobile Broadband Country Random Coefficients

Country	Model 1	Model 2	Model 3
Australia	0.073	0.069	0.068
Austria	0.058	0.058	0.057
Belgium	0.045	0.049	0.053
Canada	0.126	0.124	0.123
Czech Republic	0.069	0.075	0.069
Denmark	-0.080	-0.079	-0.081
Estonia	0.037	0.035	0.034
Finland	0.064	0.062	0.060
France	0.069	0.070	0.070
Germany	-0.342	-0.338	-0.337
Greece	0.021	0.023	0.023
Iceland	0.016	0.012	0.010
Ireland	0.034	0.031	0.034
Italy	0.063	0.068	0.074
Latvia	0.038	0.037	0.037
Luxembourg	0.058	0.057	0.057
Mexico	0.057	0.058	0.058
Netherlands	0.051	0.050	0.047
New Zealand	-0.109	-0.110	-0.109
Norway	0.002	0.004	0.004
Portugal	-0.037	-0.036	-0.036
Spain	-0.065	-0.067	-0.068
Sweden	-0.142	-0.142	-0.142
Switzerland	0.061	0.057	0.050
United Kingdom	0.076	0.075	0.075
United States	**-0.243**	**-0.241**	**-0.230**
Overall	0.000	0.000	0.000

Fig. 59. Summary Statistics for Independent Variables

Country	PPP	Exchange Rate	Fixed Usage	Mobile Usage	GNI/Capita	Non-Rural Pop. Density	Pop. Density	Educational Attainment	TRI (Weighted by Population)	Fixed Coverage
Australia	1.44	1.33	300	9.3	53,680	155	9	37.5%	0.18	66.0%
Austria	0.77	0.85	187	25.8	48,360	686	280	19.0%	1.15	82.8%
Belgium	0.74	0.85	240	3.4	45,810	1,093	984	41.8%	0.26	97.2%
Canada	1.25	1.25	335	3.4	43,540	190	11	34.4%	0.37	86.0%
Czech Republic	12.92	21.68	219	3.2	22,130	368	359	24.8%	0.58	89.2%
Denmark	6.59	6.29	323	7.2	63,010	751	377	35.5%	0.19	96.3%
Estonia	0.55	0.85		16.0	23,040	89	79	35.9%	0.19	83.5%
Finland	0.83	0.85	131	31.0	50,080	232	47	38.2%	0.27	65.0%
France	0.73	0.85	241	9.7	39,500	440	319	24.8%	0.50	65.3%
Germany	0.74	0.85	209	4.6	47,520	822	616	30.7%	0.41	89.6%
Greece	0.55	0.85	150	3.4	17,950	464	215	31.2%	1.29	54.6%
Iceland	150.64	126.99	404	16.7	62,410	540	9	38.7%	0.56	88.3%
Ireland	0.79	0.85	238	9.5	65,750	3,695	187	42.8%	0.28	87.7%
Italy	0.65	0.85	193	9.8	32,380	655	521	20.1%	0.75	77.6%
Latvia	0.51	0.85	367	23.0	17,900	168	79	34.2%	0.14	90.7%
Luxembourg	0.85	0.85		6.3	81,110	560	634	46.5%	0.58	99.4%
Mexico	10.04	20.27		4.5	8,530	607	170	18.9%	0.82	69.5%
Netherlands	0.77	0.85	180	3.7	51,070	1,297	1,342	40.6%	0.04	98.5%
New Zealand	1.49	1.41	293	4.6	41,480	44	50	36.0%	0.45	85.0%
Norway	9.67	8.59		7.3	77,880	122	38	34.3%	1.25	89.2%
Portugal	0.57	0.85	218	4.5	21,810	775	291	28.1%	0.97	92.8%
Spain	0.62	0.85	266	5.4	27,360	382	245	27.6%	0.81	93.8%
Sweden	8.71	8.58	250	12.0	54,290	319	66	34.8%	0.34	86.7%
Switzerland	1.10	0.91	224	10.5	82,620	800	566	45.3%	1.45	98.6%
United Kingdom	0.69	0.73	436	5.3	39,970	893	718	39.9%	0.21	63.2%
United States	1.00	1.00	383	7.1	64,140	252	93	39.1%	0.33	93.4%
Analysis	Both	Both	Fixed	Mobile	Both	Fixed	Mobile	Both	Both	Fixed
Source	OECD	OECD	Various	OECD	World Bank	OECD	OECD	OECD	Nunn & Puga	Various
Year	2021	2021	Most Recent	2020	2020	2014	2020	Most Recent	2000/2001	Most Recent
Unit	LCU/USD	LCU/USD	GB/Month/Subscriber	GB/Month/Subscriber	Current USD (Atlas)	People/Mile2	People/Mile2	Percentage	100s Meters	Percentage

Note: *See supra* section IV.F.1. Data and Methods Technical Details for discussion of data sources, variable construction, and details of data issues.

Fig. 60. Mobile Network Quality Variables

Country	First Principal Component	Download Speed	Upload Speed	4G Availability	5G Availability
Australia	0.23	51.0	8.6	94.4%	14.4%
Austria	-0.16	39.6	10.83	89.7%	11.6%
Belgium	-0.19	39.7	11.6	91.7%	0.0%
Canada	0.62	63.3	10.4	93.6%	12.2%
Czech Republic	0.69	42.9	16.8	92.9%	7.7%
Denmark	1.32	70.0	17.6	93.7%	0.0%
Estonia	-0.24	42.4	10.8	91.2%	0.0%
Finland	0.72	50.7	13.7	93.7%	14.4%
France	-0.51	42.0	8.2	86.8%	14.5%
Germany	0.17	44.6	11.7	92.5%	8.6%
Greece	-0.45	34.3	9.9	88.1%	13.1%
Iceland	1.19	71.0	15.0	91.8%	12.0%
Ireland	-1.92	25.9	8.8	70.9%	8.4%
Italy	-0.58	30.0	9.9	89.0%	9.7%
Latvia	-1.08	28.6	8.9	86.3%	0.0%
Luxembourg	0.86	56.0	13.6	94.5%	13.6%
Mexico	-1.42	21.2	8.2	85.0%	0.0%
Netherlands	1.71	75.3	15.6	96.9%	13.9%
New Zealand	-0.58	37.7	10.3	87.5%	2.5%
Norway	1.66	77.8	15.8	97.3%	6.5%
Portugal	-0.05	43.0	11.9	87.7%	13.1%
Spain	-0.69	29.0	9.6	88.4%	8.5%
Sweden	0.29	46.2	12.9	93.5%	3.2%
Switzerland	1.22	57.2	17.1	93.5%	13.8%
United Kingdom	-1.12	28.0	7.0	86.9%	7.1%
United States	0.31	43.1	8.1	97.7%	21.3%
Analysis	Mobile	Mobile	Mobile	Mobile	Mobile
Source		Opensignal	Opensignal	Opensignal	Opensignal
Year		Most Recent	Most Recent	Most Recent	Most Recent
Unit	Standardized	Mbps	Mbps	Percentage	Percentage
Loading Factor		0.6143	0.5602	0.5165	0.2052

Fig. 61. Content Quality Variables

Country	First Principal Component	Webpages by TLD Per Capita	Domains by TLD Per Capita	TLD	EPI	Content Language	Language Assumed
Australia	1.50	22.84	0.13	.au	10.0%	61.8%	English
Austria	-0.54	30.17	0.16	.at	64.1%	3.0%	German
Belgium	-0.62	23.03	0.14	.be	62.9%	1.2%	Dutch
Canada	1.38	17.31	0.08	.ca	10.0%	61.8%	English
Czech Republic	-0.47	33.08	0.13	.cz	56.3%	0.3%	Czech
Denmark	-0.40	28.15	0.25	.dk	63.6%	0.3%	Danish
Estonia	-0.26	80.48	0.11	.ee	58.1%	0.1%	Estonian
Finland	-0.69	27.67	0.09	.fi	61.8%	0.2%	Finnish
France	-0.63	17.97	0.06	.fr	55.1%	2.9%	French
Germany	-0.46	21.64	0.20	.de	61.6%	3.0%	German
Greece	-0.81	13.73	0.04	.gr	59.1%	0.2%	Greek
Iceland	-0.02	102.60	0.21	.is	62.9%	0.1%	Icelandic
Ireland	1.35	19.83	0.06	.ie	10.0%	61.8%	English
Italy	-0.62	20.02	0.05	.it	53.5%	1.4%	Italian
Latvia	-0.69	19.94	0.07	.lv	56.9%	0.1%	Latvian
Luxembourg	-0.43	35.53	0.16	.lu	60.4%	3.0%	German
Mexico	-0.57	2.80	0.01	.mx	43.6%	3.8%	Spanish
Netherlands	-0.28	27.75	0.33	.nl	66.3%	1.2%	Dutch
New Zealand	1.51	20.81	0.14	.nz	10.0%	61.8%	English
Norway	-0.47	50.19	0.15	.no	63.2%	0.1%	Norwegian
Portugal	-0.86	17.67	0.04	.pt	62.5%	0.9%	Portuguese
Spain	-0.62	18.10	0.04	.es	54.0%	3.8%	Spanish
Sweden	-0.60	29.17	0.14	.se	62.3%	0.4%	Swedish
Switzerland	-0.13	36.47	0.28	.ch	57.5%	3.0%	German
United Kingdom	1.53	16.85	0.16	.uk	10.0%	61.8%	English
United States	2.89	111.32	0.56	.us / .com / .net / .org	10.0%	61.8%	English
Analysis	Both	Both	Both	Both	Both	Both	Both
Source		Google	Domain Tools		Education First	W3Techs	
Year		2022	2022		2021	2022	
Unit	Standardized	Webpages by TLD Per Capita	Domains by TLD Per Capita		Percentage	Percentage	
Loading Factor		0.2225	0.3332		-0.6385	0.6571	